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POSTURAL FAULTS IN SCHOOL CHILDREN

A Physiotherapeutic Approach

Birgitta Johnsson



POSTURAL FAULTS IN SCHOOL CHILDREN - a physiotherapeutic approach

by

Birgitta Johnsson
Leg sjukgymnast, Vg

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Abstract Postural problems in children are a matter of concern for professionals in medicine, for persons in the child's environment and to some extent to the child himself. The aim of the study was to analyse the frequency of postural faults in school children and their relation to back pain, and, further, to find out whether children with postural faults differ from a matched control group with respect to flexibility, muscle function and interest and participation in physical activities and in school work. A further aim was to compare objective registrations of posture with subjective assessments, and, finally, to investigate the effect of postural gymnastics on postural faults, flexibility and muscle function. Five hundred and eighty nine school children in classes 1,4,7 and 9 were examined. Eleven percent, in equal numbers of boys and girls, were regarded as having postural faults. The frequency increased with age. Twelve percent of the children had back pain, significantly more girls than boys. Back pain was more frequent in children with postural faults. Pain from parts of the locomotor system other than the back was reported in 17% of the material. Objective registrations (spinal pantography and moiré topography) could verify subjective assessments of posture (direct assessment and photographs) with respect to the degree of thoracic kyphosis and lumbar lordosis and the anterior-posterior deviation of the trunk. Children with postural faults had an inferior trunk muscle strength, a defective coordination and shortened hamstrings. Further, they were given lower marks by their gymnastics teachers and class teachers than children in the control group. Conventional postural gymnastics had no effect on postural faults, flexibility, muscle strength and coordination. Muscle tightness, however, was reduced. Postural faults are only a part of a multi-problem situation and major attention should therefore be paid to the child, with his individual characteristics and personality, in his interaction with his total environment.			
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INTRODUCTION

Postural problems in children are a matter of concern for both professionals in medicine, for persons in the children's environment, such as teachers and parents, and to some extent for the child himself.

Postural faults have been supposed to contribute to back problems in childhood and adolescence, as well as later in adult life.

Great interest has therefore been focused upon corrective exercises, as well as on giving instruction aimed at improving sitting and standing posture. In addition to this, improvements in the adaptation of school furniture to the body proportions of the children have been introduced, especially in recent decades.

Remarkably few investigations, however, have been carried out to evaluate the effect of corrective exercises or other measures (Johansson 1953, Ingelmark 1954, Arnesen et al. 1976 and Dullum and Goldschmidt 1976).

Furthermore, in different investigations one finds a great variability concerning the occurrence of postural faults. Matthiass (1966) reported 95% of 1032 adolescents as having a posture which deviated from so-called normal, harmonious posture. Seyffarth (1972) considered that out of 229 children in the first school-class, i.e. 6 to 7 years of age, 95% had unsatisfactory posture. On the other hand Cronis and Gleeson (1974) found, in a screening of 3282 school children, only approximately 13% with postural deviations such as increased kyphosis and lordosis and poor posture.

These great discrepancies concerning the occurrence of postural faults in school children must be regarded as the result of both a difficulty in assessing body posture and in defining the postural fault.

There is, thus, a great need for simple and useful definitions of posture and of postural faults (Brown 1917 and Wells 1966).

Methods for quantifying postural faults would also be of great importance.

Back pain in adult life is a significant health problem with considerable socio-economic implications. It has, therefore, been suggested that prevention should start already in childhood, including treatment of postural faults (Kornfält 1981).

Despite a widespread opinion that postural faults might give rise to back problems in childhood and adolescence, very little has been done to elucidate a possible connection. Results reported by Brown (1917) indicate a low incidence of back pain in subjects with postural faults. In adult subjects, no definite correlation between back pain and postural abnormalities has been demonstrated (Arbeterskyddsfonden 1976).

There are also very divergent opinions as regards possible causes of postural faults in children. Trunk muscle strength and muscle balance are assumed by some investigators to be the most important factors (Bang and Bojlén 1950, Kendall and Kendall 1968, Rasch and Burke 1978).

Other authors consider muscle tightness and lack of mobility of the spine to be important factors in the development of postural faults (Burt 1949, Bang and Bojlén 1950, Schellnack and Hähnel 1982).

Postural habits, for example sitting or standing in a slumped position, incorrect clothing, and lack of exercise are considered by others to have a negative influence on the posture of the child (Bang and Bojlén 1950, Wiles and Sweetnam 1965, Rasch and Burke 1978).

Psychological factors, such as depression, anxiety, lack of self-confidence, psychological fatigue or mental strain are considered by many authors to be by far the most important causes of abnormal habitual posture in childhood (Wiles and Sweetnam 1965, Wells 1966, Roaf 1977 and Rasch and Burke 1978).

Physiotherapists are usually responsible for the instruction and training of school children with postural faults, and are in many places affiliated to schools for this purpose. Despite their experience in the assessment of locomotor function and in postural re-education, they have been involved to a very limited extent in research work in this field.

LITERATURE REVIEW

During the past century many investigations have been carried out concerning posture and postural faults in childhood and adolescence.

Many of the authors have been interested mainly in describing divergences from the so-called normal or average posture (table 1).

Definitions of postural faults

Some difficulties arise when trying to compare results from different studies, as there are often as many definitions and descriptions of postural faults as investigations.

Two norms, however, more or less revised, have been referred to by several investigators. One is the classification of posture into five different types, designated according to Staffel (1889), in translation from the German, as: normal posture, sway-back, flat back, increased lordosis and generally increased sagittal curves of the spine.

The other norm is the recommendations made by the Department of Hygiene and Physical Education, Harvard University (1916), grading posture from A to D, where A stands for "excellent mechanical use of the body", and D stands for "very poor mechanical use of the body".

Assessment of posture

Instruments and methods to evaluate and assess posture and to register the sagittal curves of the spine have been invented and used by many.

A common method to assess a faulty position of the body is to describe the deviation from the plumb line (Staffel 1889, Kirchhoff 1893, Engelhard 1910, Burt 1949, Mólhave 1958, Lowman and Young 1960, Tucker 1960, Asmussen and Klausen 1962, Arnesen et al. 1976 and Galley and Forster 1982).

Different kinds of devices have been used to assess the ranges of the sagittal curves. Ingelmark (1954) and Wolánski (1964) invented similar instruments with movable pegs, which, touching the back of the child, could give a good description of the contour of the spine.

X-rays have been used, sometimes as an isolated method, but also as a complement to other methods, in describing postural faults (Flint 1963, Winter and Hall 1978, Fon et al. 1980, Menge 1982 and Stagnara et al. 1982).

There are, further, a great number of devices of almost the same construction i.e. that of a goniometer, but with as many names as inventors. An inclinometer was used by Leighton (1942), Asmussen and Heebøll-Nielsen (1958), Heebøll-Nielsen (1958), Asmussen and Klausen (1962), Wiles and Sweetnam (1965), Loeb1 (1967) and Stagnara et al. (1982).

Kyphometers, kypholordometers and spondylometers for objective registration of the range of kyphosis and lordosis have been used by Dunham (1949), Debrunner (1972), Sturrock et al. (1973), Hart et al. (1974), Hähnel et al. (1981), Spangfort (1981), Schellnack and Hähnel (1982) and Wredmark et al. (1983). Timm (1969, 1971) used a so-called curve ruler, a flexible ruler with a plumb-rule attached at the lower end.

Side-view photographs have been proposed and used both in order to evaluate the posture of the subject and in before-and-after-therapeutic-exercises documentation. (Brown 1917, Fradd 1923 Haglund 1923, Fox 1951, Johansson 1953, Ingelmark 1954, Flint and Diehl 1961, Flint 1963, Matthiass 1966, Arnesen et al. 1976 and Suzuki et al. 1981).

Engelhard (1910) invented an instrument with which the contour of the spine was drawn on a vertical glass screen. Tichauer et al. (1973) used a device named lordosimeter, and a spinal pantograph was used by Willner (1981) to register the sagittal curves of the spine. The method of using a moiré technique to describe the curves in the sagittal plane was reported by Suzuki et al. (1981).

Many investigators consider the pelvic inclination as the determining factor for the postural contour of the spine. There are, however, some difficulties in comparing the results of these studies, due to discrepancies in the subjective assessment as well as in the measuring technique. Sanders and Stavarakas (1981) developed a very useful method to make exact calculations of the angle between the posterior superior iliac spine (PSIS) and the anterior superior iliac spine (ASIS). Engelhard (1910) used the same points of reference in his study. Lowman and Young (1960) considered the pelvic tilt as normal when ASIS and the upper margin of the symphysis pubis were in the same vertical plane.

Møhlhave (1958), Asmussen and Klausen (1962), Wiles and Sweetnam (1965) and Williams (1965) proposed that the angle to determine the pelvic inclination should be calculated from PSIS to the upper border of the symphysis pubis.

Measurement of spinal mobility

Testing the mobility of the spine is regarded by many investigators as a necessity when assessing posture. Using a steel or a plastic measuring tape, variations of the technique once suggested by Schober (1937), have been used in many examinations (Dürrigel 1965, Macrae and Wright 1969, Moll and Wright 1971, van Adrichem and van der Korst 1973 and Frost et al. 1982). Further, this measuring method is recommended by The American Academy of Orthopaedic Surgeons (1965). Macrae and Wright (1969) also used X-rays to determine the accuracy of

the tape measuring method. X-rays to determine the sagittal segmentary mobility of the lumbar spine were used by, among others, Aho et al. (1955).

The devices described previously for recording posture have in many studies also been used for measuring the sagittal mobility of the spine (Engelhard 1910, Leighton 1942, Dunham 1949, Asmussen and Heebøll-Nielsen 1958, Asmussen and Klausen 1962, Flint 1963, Loebl 1967, Timm 1969, Debrunner 1972, Sturrock et al. 1973, Hart et al. 1974, Arnesen et al. 1976, Spangfort 1981 and Wredmark et al. 1983).

Reynolds (1975) compared the three most common methods for measuring spinal mobility. The spondylometer, originally described by Dunham (1949), the inclinometer as described by Loebl (1967) and the skin distraction test (the tape measuring method) devised by, among others, Macrae and Wright (1969) and based on the original work of Schober (1937). Harris (1969), presented a literature review covering different methods of measuring flexibility.

Seyffarth (1972) pointed out the necessity of registering the mobility of the spine in the assessment of posture, even without any specific measuring instruments.

Assessment of muscle strength

Muscle strength, especially the strength of the trunk muscles, is assumed by some authors to be a very important factor in maintaining a good posture, but remarkably few investigators have included muscle strength tests in their studies concerning posture and postural faults (Fox 1951, Asmussen and Heebøll-Nielsen 1958, Flint and Diehl 1961, Flint 1963, Arnesen et al. 1976 and Schellnack and Hähnel 1982).

However, there are some difficulties in comparing the results of the muscle strength tests, as no standardized techniques or positions during the measurements have been adhered to. Seyffarth evaluated muscle strength by the manual resistance applied.

Assessment of muscle tightness and coordination

Muscle tightness, especially that of hip and shoulder joints, has been tested by Bang and Bojlén (1950), Seyffarth (1972) Arnesen et al. (1976), Frost et al. (1982) and Schellnack and Hähnel (1982).

Coordination, i.e. the normal interplay between different muscle groups, has not been tested functionally by any of the authors in this literature review.

Postural exercises

Postural exercises have been advocated by many authors to improve posture and to eliminate postural faults, but few investigations have been carried out to evaluate the effect of these efforts (introd. pg. 7).

Conclusion

Thus, a great deal has been written about posture and postural faults in children, adolescents and in adults, during the past century.

Few investigators, however, have made an attempt to assess and classify posture and postural faults in order to relate these subjective assessments to objective measurements of

posture, as well as, for example, to spinal mobility and muscle function. Further, only a few of these (Brown 1917, Burt 1949, Engbaek 1974, Spangfort 1981 and Wredmark et al. 1983) have tried to find out whether there is a correlation between postural faults and the development of back pain or not. On the other hand, corrective exercises are often recommended in order to prevent back problems in adult life.

Some authors (introd.pg. 9) consider psychological factors to be of the greatest importance in the development of postural divergences. There is, however, a sparcity of studies with respect to these factors, where attempts have been made to find possible causes and to suggest appropriate treatment or to evaluate the effect of this treatment.

Thus, there are still many questions to be answered in order to gain a better understanding of the child with a postural fault, with respect to classification and objective measurements of posture and possible causes of postural divergences. In addition to this, we should aim at gaining a better insight of whether postural faults contribute to back problems in later life, and further, if this appears to be the case, we should make an effort to design effective treatment.

Table 1. Studies on posture and postural faults.

Authors	Years of publ.	Number of subjects		Assessment of posture	Measure-ment of posture	Measure-ment of			Assessment of		Postural exercises
		child- ren	adults								
Staffel	1889			x	x				muscle tight- ness	coordi- nation	
Kirchoff	1893			x	x						
Engelhard	1910			x	x						
Brown	1917			x	x						
Fradd	1923			x	x						
Burt	1949			x	x						
Bang and Bojlen	1950	1300		x					x		x
Fox	1951			x	x						x
Johansson	1953	297		x	x						x
Ingelmark	1954	445		x	x						x
Heebøll-Nielsen	1958	201		x	x			x			
Mólhave	1958			x	x						
Asmusen and Heebøll-Nielsen	1958	201		x	x			x			x
Lowman and Young	1960			x	x						x
Tucker	1960			x	x						
Flint and Diehl	1961	210		x	x						
Asmusen and Klausen	1962			x	x						

Authors	Years of publ.	Number of subjects		Assessment of posture	Measurement of posture	Measurement of		Assessment of		Postural exercises
		child- ren	adults							
Flint	1963		31	x	x	spinal mobility	x	muscle tightness		
Wolanski	1964	6200		x	x					x
Williams	1965			x	x					
Wiles and Sweetnam	1965			x	x					x
Matthiass	1966			x	x					
Wells	1966			x	x					x
Loebl	1967		-176-	x	x		x			
Kendall and Kendall	1968			x						x
Timm	1969	250		x	x		x			
Timm	1971	800		x	x		x			
Seyffarth	1972	567		x				x		x
Cronis and Gleeson	1974	3282		x						
Engbaek	1974	4367		x						
Arnesen et al.	1976	377		x	x		x	x		x
Dullum and Goldschmidt	1976	114		x						x
Roaf	1977			x						
Rasch and Burke	1978			x						x

Authors	Years of publ.	Number of subjects		Assessment of posture	Measurement of posture	Measurement of		Assessment of	Postural exercises
		child- ren	adults			spinal mobility	muscle strength	muscle tight- ness	
Winter and Hall	1978			x	x				
Hähnel et al.	1981	320		x	x				
Suzuki et al.	1981	-3044-		x	x				
Galley and Forster	1982			x	x				x
Schellnack and Hähnel	1982	-1300-		x	x		x	x	
Present study	1983	589		x	x	x	x	x	x **)
		179		x	x				

*) 133 subjects

**) 35 subjects

AIM OF THE STUDY

It was the aim of the present study to answer the following questions:

1. How is the term "postural fault" to be defined, so that it can have a practical use in school health care?
2. How frequent is the occurrence of postural faults, of such severity that they are regarded as requiring postural gymnastics?
3. Is there a connection between postural faults and back pain?
4. Do objective measurements of posture and postural faults agree with direct subjective assessments of posture?
5. Do children with postural faults differ from a control group with respect to physical variables such as flexibility of the spine, trunk muscle strength, muscle tightness and coordination?
6. Do postural gymnastics in a short-term follow-up have an effect on postural faults or on the previously mentioned physical variables?
7. Do children with postural faults differ from a control group with respect to interest and participation in physical activities and in school work?

STATISTICAL METHODS

Basic statistical methods were used, such as the t-test for groups and paired observations and the chi-square test. Correlation coefficients and linear regression equations were also calculated.

I. ASSESSMENT AND FREQUENCY OF POSTURAL FAULTS

It was the aim of this part of the investigation to define the term "postural fault" and to study the frequency of postural faults and the occurrence of back pain and pain from parts of the locomotor system other than the back.

MATERIAL

The investigation in its first stage includes a total of 589 pupils in school-classes 1, 4, 7 and 9 (i.e. mean ages 7, 11, 14 and 16 years, respectively) at Järnåkra School in Lund, and was initiated in 1977. Follow-up and re-examinations of the original material, as well as complementary examinations were continued until 1982.

Järnåkra School in Lund comprises upper-, middle- and lower-school stages of the elementary school and, together with 3 other schools with only middle- and lower-school stages, comprises the Rectoral Area of Järnåkra with a total of 1.100 pupils.

The social structure, measured according to such variables as child density, housing standard, income, frequency of shifting house, proportion of immigrants and the amount of social aid accepted, indicates that the Rectoral Area of Järnåkra can be taken as representing the average for the whole town of Lund (Lindh and Olsson 1977). The town, however, is not representative for the whole country. People with higher education are heavily over-represented in this area (Köhler 1973).

The school nurse is employed full-time, and the school doctor works at the school for 3.5 hours per week, i.e. somewhat less than the 5 hours per 1.000 pupils recommended by the National Board of Education (Official Report on School Health Care, 1976). Both the nurse and the doctor, who is a trained pediatrician, have worked at the school for more than ten years.

In the schools of this area, a school psychiatrist and physiotherapists are employed part-time, but no social worker is employed.

The classes 1, 4, 7 and 9 were chosen for the investigation because the school doctor carries out a routine health examination in these classes. All pupils in these classes were included in the study, thus no selection was made. The distribution of the material according to school-class can be seen in fig. 1.

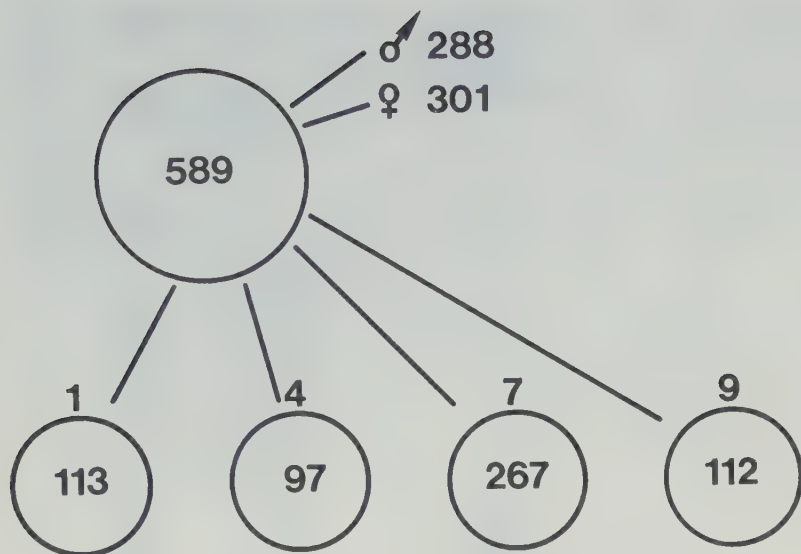


Fig. 1. Distribution according to school-classes.

METHODS

Assessment of posture

In conjunction with the routine health examination, the pupils' posture was assessed by the school doctor, the school nurse and by the author. The assessments were made independently, and the aim was to find those pupils who were regarded as requiring postural gymnastics. The assessment grades "Postural fault" (PF), "doubtful PF" and "no PF" were noted on a test card for each pupil.

On this test card, observations of particular deviations in the pupil's posture could be noted, such as pronounced kyphosis, and/or lordosis, flat back, scoliosis, difference in leg length, or faulty positioning of feet or knees.

After each class had been examined in this way a comparison of our results with respect to the assessment of posture was made. In those cases where there was disagreement in the assessment,

the examination of the pupil was repeated, this time by the three examiners together.

337 pupils were examined initially in this way, and the results showed relatively good agreement in our assessments. The agreement was practically the same in all the age groups examined. In the case of 254 pupils (75%), agreement in the assessments was complete. In only 3% was there complete disagreement.

Based on this result, a description could be made according to which the pupils requiring postural gymnastics could be picked out with greater certainty. With this description as a basis, the assessment of the posture of the remaining pupils in the investigation was carried out by the school nurse and the author only.

Assessment of difference in leg length

The assessment of leg length was carried out by having the children stand in an upright, relaxed position, balancing equally on both feet, looking straight ahead (fig. 2).

The posterior superior iliac spines (PSIS) were palpated from below to determine their level. Also the anterior superior iliac spines (ASIS) were palpated to avoid misjudgement caused by any rotation of the iliac bone on one side.

If the PSIS and the ASIS on the same side were situated lower than on the opposite side then a lumbar scoliosis with the convexity towards the same side as the short leg was, as a rule, also seen.

Any difference in leg length was compensated using wooden boards 2.5 and 5 mm in thickness, until PSIS and ASIS were palpated at the same level on both sides.

If there was only a leg length discrepancy with an accompanying functional, static scoliosis, this scoliosis was eliminated as a result of the correction.

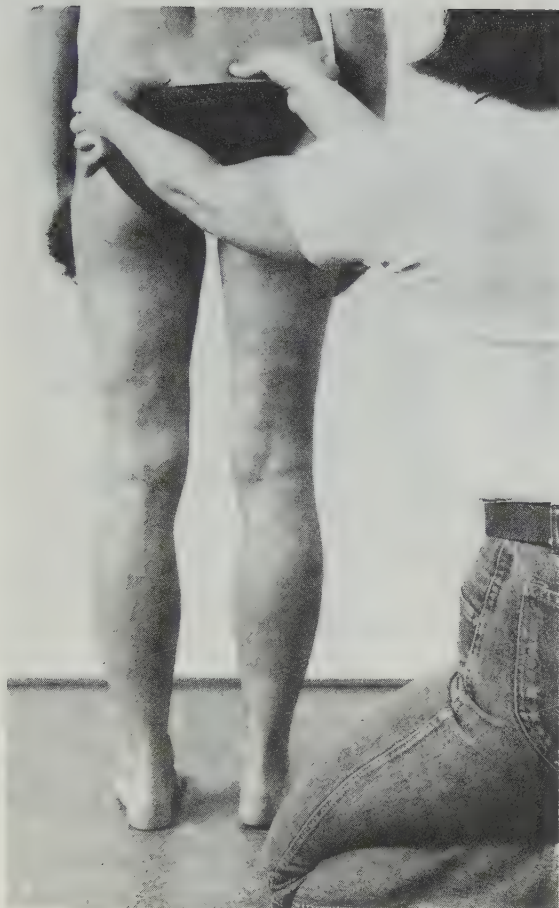


Fig. 2. Assessment of difference in leg length.

The discrepancy of leg length was re-checked by having the child bend forward. By studying the tilt of the sacrum in the frontal plane with and without the compensation of the wooden boards it was easy to see whether the difference in leg length was accurately assessed and corrected or not.

In this investigation only leg length discrepancies of 5 mm or more were recorded.

Assessment of structural scoliosis

The children were examined standing in an upright, relaxed position, equally balanced on both feet, looking straight ahead.

The following points were checked:

- the level of the shoulders
- the position of the shoulder-blades with respect to the right side and the left side, and to the distance to the spinal processes in between
- the deviation of the spinal processes from the midline, (=deviation from the plumb line)
- the asymmetry of the trunk contours
- the asymmetry of the thorax

The child was then asked to bend forward. Standing in front of the child, with the observer's eyes at the level of the child's back, any asymmetry of the thoracic or lumbar spine could easily be discerned.

The degree of rotation of the scoliosis was assessed in the following way:

A wooden board was held horizontally touching the most prominent hump of the scoliosis and covering the opposite side of the rib cage. On this side of the spine a mark was made at the same distance as that from the spine to the hump. The vertical distance between this mark and the board was then measured. Only differences of 5 mm or more were taken into account, (fig. 3).



Fig. 3. Assessment of structural scoliosis.

Inquiry by questionnaire

The pupils themselves, and in the younger age groups with the help of their parents, were asked via a questionnaire, to supply information concerning the occurrence, frequency and type of back pain, other complaints or injuries, involving in particular the locomotor system. Further they, or their parents, were asked to give an appraisal of whether their posture was "good" or "bad". They were also asked whether they had previously taken part in postural gymnastics.

RESULTS

Assessment of posture

In connection with the definitions of divergent posture at which we arrived on the basis of the class health examinations, we aimed at achieving a differentiation between so-called postural faults and such postural deformations and postural irregularities which could not be expected to respond to postural gymnastics.

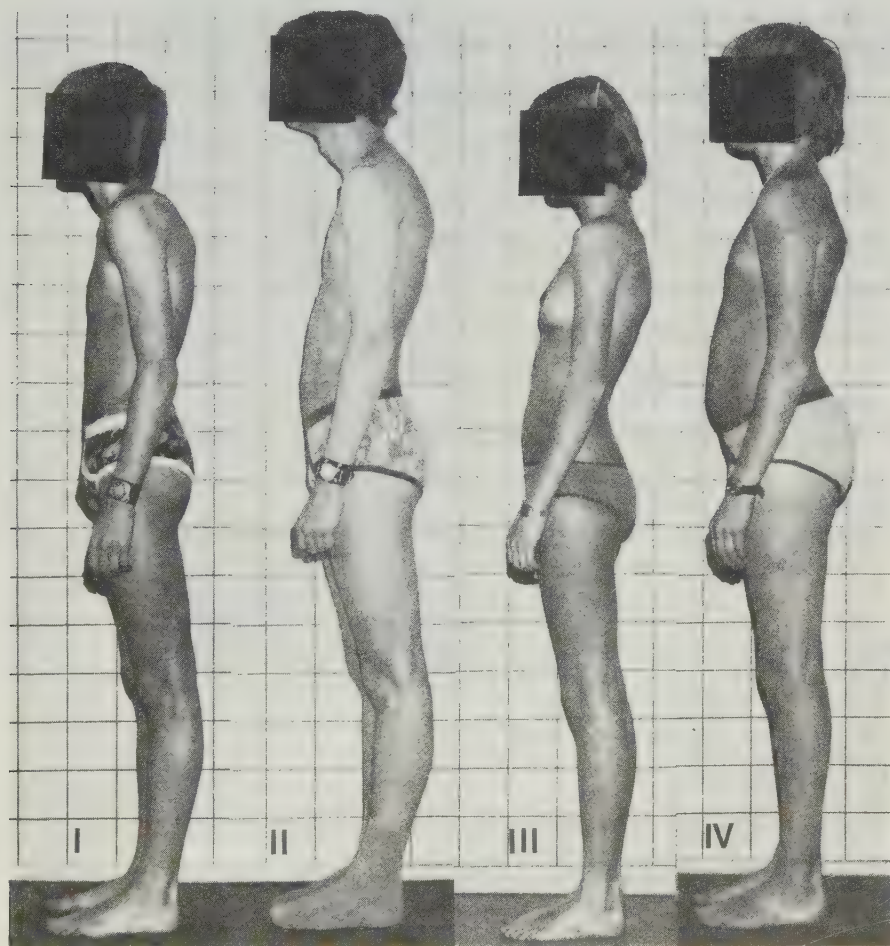


Fig. 4. Postural faults type I, II, III, IV.

Below, the various types of postural faults, termed type I, II, III and IV and the most characteristic features of each type are described (fig. 4).

Type I

- The head is jutting forward.
- The upper back is rounded, i.e. there is an increased kyphosis.
- The chest is depressed.
- The shoulders are rounded, i.e. the scapulae are abducted.
- The arms are often rotated inward.
- The lower back is often of a normal configuration.

Type II

- The lumbar lordosis is increased.
- The pelvis has an increased anterior tilt, or there is a forward sway of the pelvis and the hips.
- The abdomen is protruding.

These features are most often accompanied by:

- Increased kyphosis
- Depressed chest
- Rounded shoulders
- Head jutting forwards
- Hips and knees in hyperextension.

Type III

- There is a posterior deviation of the upper trunk.
- The thoracic kyphosis is slightly increased.
- The head is jutting forward.

These features often occur in combination with:

- A forward sway of the pelvis and of the upper legs.

This posture is often called "sway-back".

Type IV

- The pelvis has an increased anterior tilt.
- The lumbar lordosis is increased.
- There is a flexion of the hip joints.
- The knees are in flexion or hyperextension.

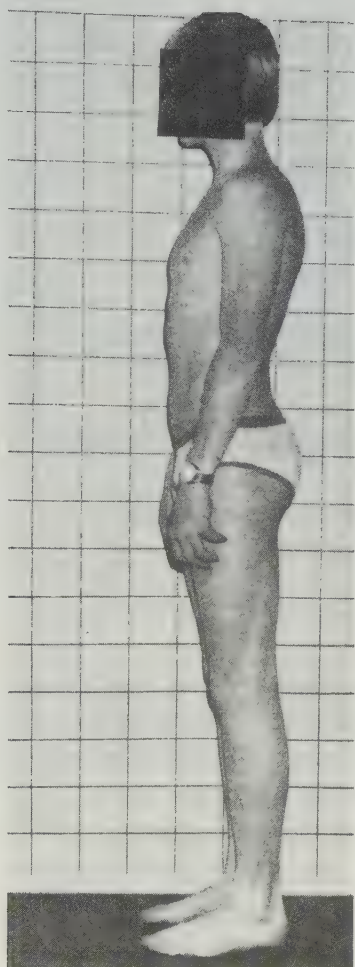


Fig. 5. "Normal posture".

In contrast to the postural faults mentioned above, "normal" posture, (fig. 5) i.e. the posture which most individuals have, and which is well-balanced and in equilibrium, is defined as follows:

- There is a slight anterior pelvic tilt. The PSIS (posterior superior iliac spines) are slightly cranial to the ASIS (anterior superior iliac spines), and the symphysis and the ASIS are in the same vertical line.
- The hips are midway between a forward and a backward tilt.
- The legs are vertical.
- The knees are erect, but still at ease.
- The lordosis and kyphosis are moderate.
- The abdominal wall is flat.
- The chest is held moderately elevated, thus making the sternum the most forward part of the trunk.
- The upper back is erect.
- The head is erect.
- The shoulders are held moderately backward, i.e. the scapulae are slightly adducted.

Of the 589 pupils comprising the material of the investigation, 67 pupils, (11%), 34 boys and 33 girls, were judged to have such postural faults that he or she required so-called postural gymnastics. There was almost an equal number of boys as of girls in the school-classes investigated, who were judged to have divergent posture, and the number of pupils with postural faults increased with age, fig. 6.

On dividing the pupils according to different types of postural fault, it was found that type II was the most common. As fig. 7 illustrates, there was also a certain difference concerning the type of postural fault, in a comparison between boys and girls. The number of pupils in each group, however, was too small to allow any statistically certain conclusions to be drawn from these results. The various types of postural faults occurred in all age groups.

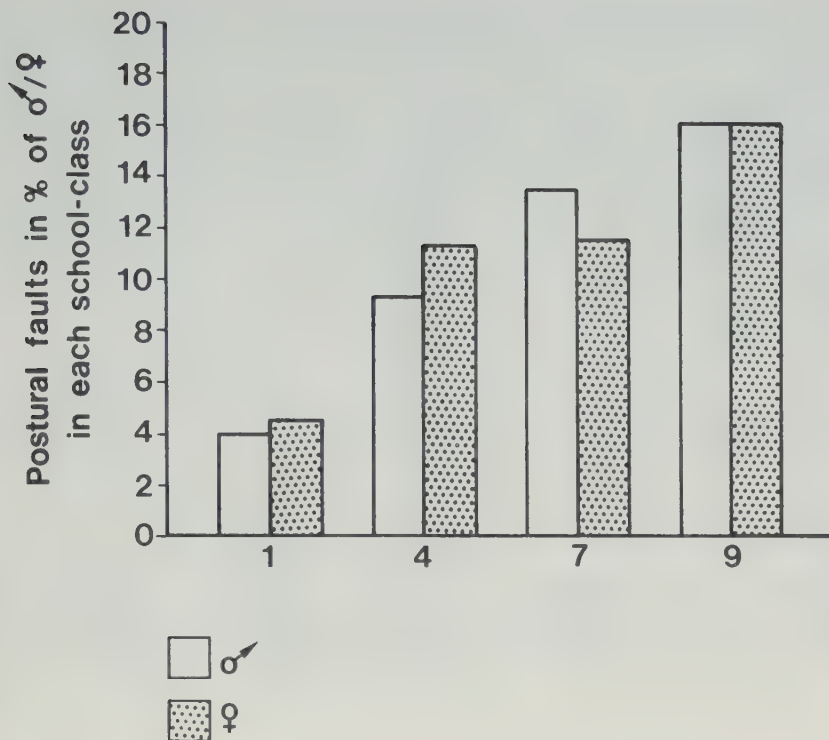


Fig. 6. Distribution of postural faults according to school-classes, (1, 4, 7 and 9), and sex.

Difference in leg length

A total of 153 pupils, (26%), 74 boys and 79 girls, of the 589 pupils making up the entire material had a difference in leg length of at least 5 mm. In only three cases was a difference in the length of the legs of more than 10 mm measured. There were significantly more pupils in the older age groups, 121 out of 379 pupils, (32%), than in the younger age groups, 32 out of 210 pupils, (15%), with differences in leg length, $p = 0.02$.

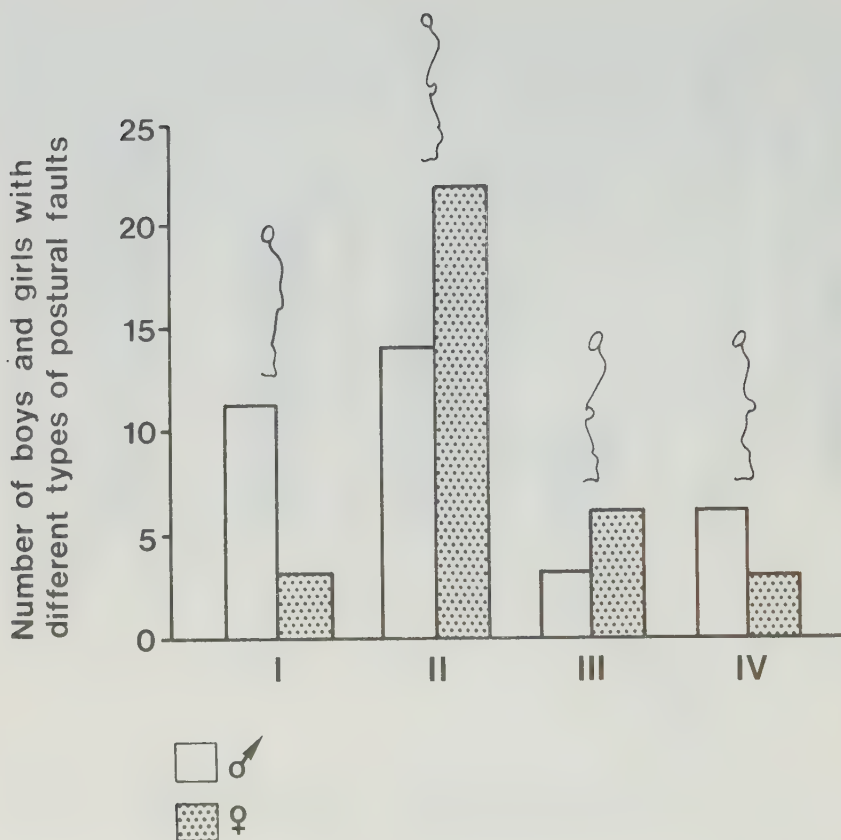


Fig. 7. Distribution of the different types of postural faults according to sex.

There were 78 of the 153 pupils who had their right leg shorter and the remaining 75 pupils had their left leg shorter. In the younger age groups 20 of the 32 pupils had a short left leg and 12 pupils had a short right leg. Among the pupils in the older age groups there was a slight dominance of shorter right legs. There were 66 out of the 121 pupils in classes 7 and 9 who had a shorter right leg, while the remaining 55 pupils had a shorter left leg.

Of the 67 pupils in the postural fault (PF) group, 23 individuals, (34%), 15 girls and 8 boys, had legs of different lengths. Thus, there were somewhat more pupils in the PF group than in the remainder of the material (25%) with a difference in the length of their legs. However, this difference between the PF group and the remainder of the material was not significant.

Structural scoliosis

There were 122 pupils of the total material of 589, (21%), 53 boys and 68 girls, who were assessed to have a structural scoliosis. One girl in the older age group had been operated on account of the scoliosis.

Structural scoliosis occurred in all age groups, but there were significantly more pupils in the older age groups, (27%), than in the younger age groups, (10%), who had scoliosis, $p = 0.01$.

On dividing the material according to age and sex, it was found that in the younger age groups there were more boys than girls, 13 compared to 8, while in the older age groups more girls than boys, 61 compared to 40, who had scoliosis. The difference between boys and girls was, however, not significant for any age group, (table 2).

There were significantly more pupils in the PF group than in the remaining material who had a structural scoliosis, $p < 0.05$. Out of the 67 pupils in the PF group, there were 21 pupils, (31%), 12 boys and 9 girls, who had scoliosis, and of the remaining pupils in the material there were 101, (19%), who had scoliosis.

Table 2. Distribution of the number of subjects with structural scoliosis according to age and sex.

	Class 1 Mean age 7 years ♂ ₄₉ ♀ ₆₄	Class 4 Mean age 11 years ♂ ₅₃ ♀ ₄₄	Class 7 Mean age 14 years ♂ ₁₃₀ ♀ ₁₃₇	Class 9 Mean age 16 years ♂ ₅₆ ♀ ₅₆	Total ♂ ₂₈₈ ♀ ₃₀₁
Boys	6 (12%)	7 (13%)	28 (22%)	12 (21%)	53 (18%)
Girls	3 (5%)	5 (11%)	41 (30%)	20 (36%)	69 (23%)
Total	9 (8%)	12 (12%)	69 (26%)	32 (29%)	122

Dividing the PF group according to type of postural fault, it was found that scoliosis occurred in all types of postural fault. There was no statistical correlation between the frequency of occurrence of scoliosis and the type of postural fault.

There were 86 out of the 122 pupils who had a C-shaped scoliosis. In 47 of these cases the convexity was to the right, and in 39 cases the convexity was to the left. There was some predominance of the convexity to the right in both the younger and the older age groups.

Thirty-five pupils had an S-shaped scoliosis, of whom 17 individuals had the thoracic convexity to the right side, while 18 individuals had a left-sided thoracic convexity. There were significantly more pupils in the older age groups than in the younger age groups who had an S-shaped scoliosis, $p = 0.05$.

In the lower classes, 4 out of the 21 pupils, (19%), with scoliosis, had an S-shaped scoliosis, while among the 101 pupils in the upper classes, this type of scoliosis occurred in 31 cases, (31%).

Correlation between structural scoliosis and difference in leg length

There were significantly more pupils who had both scoliosis and a difference in leg length, $p = 0.01$. Out of the 122 pupils with scoliosis 52 individuals, (43%), had a difference in the length of their legs. Of the remaining pupils without scoliosis a difference in leg length occurred in 101 cases, (22%), (table 3).

Table 3. Distribution of the number of subjects with and without structural scoliosis according to occurrence of difference in leg length.

	No difference in leg length	Difference in leg length	Total
No scoliosis	366	101	467
Scoliosis	70	52 ^{x/}	122
Total	436	153	589

x/ $p = 0.01$.

Furthermore, there was a good correlation between the side of the shorter leg and the side of the convexity of the scoliosis. In 74% a short left leg was associated with a C-shaped scoliosis to the left or an S-shaped scoliosis with the lower convexity to the left, and a short right leg was associated in the same way with the convexities of the scoliosis to the right. The remaining cases of 26% were exceptions to this rule.

Results of the questionnaire

In conjunction with the class health examination, an additional question was put to the pupils, namely, how long and how frequently they suffered from back pain. This was done as a complement to the answers in the questionnaire and in order to exclude those pupils who had had back pain for only one or two days on a single occasion or in conjunction with, for example, a minor fall or accident.

The girls were also queried as to whether their back pain was correlated to the time of ovulation and menstruation and, where this appeared to be the case, these pupils were excluded from the back-pain group. The majority of the pupils had only visited the school nurse or the school doctor with their back pain and/or pain and complaints in other parts of the locomotor system. Approximately 5% had been sent to an orthopaedic specialist for further examination and treatment, and about 10% had been referred to a physiotherapeut, mainly for pain treatment and instruction.

a. Back pain

All pupils filled in the questionnaire.

After exclusion of those types of back pain mentioned above, altogether 69, (12%), of the 589 pupils indicated that they suffered from back pain, and of these, more than 95% indicated the lumbar spine as the site of the complaint.

No pupils in class 1 (i.e. among the 7-year-olds) indicated back complaints, while in particular pupils in classes 7 and 9 complained of back pain. The distribution of the material according to back pain is illustrated in fig. 8.

As can be seen in table 4, there was a marked difference in the frequency of back pain between boys and girls,
 $p < 0.001$.

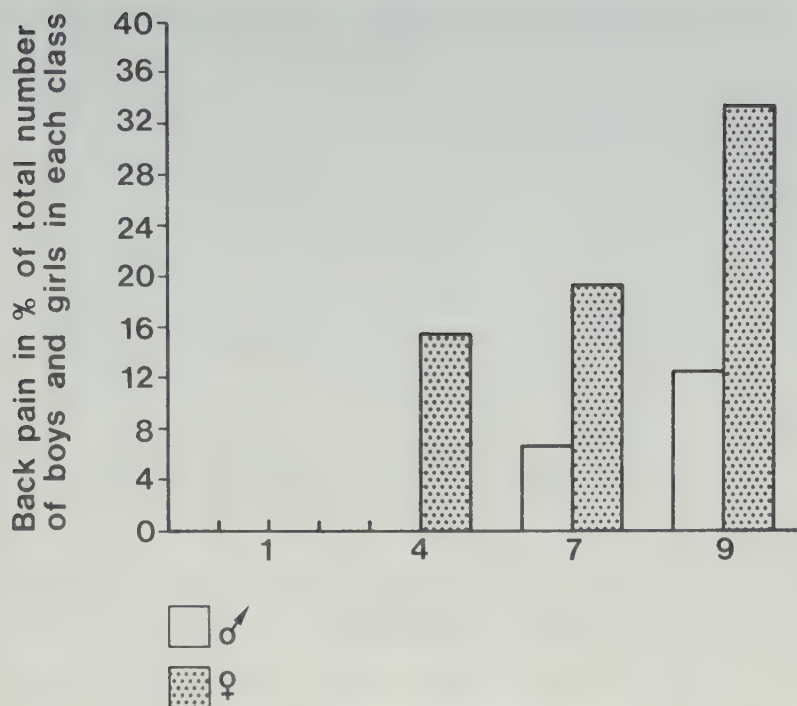


Fig. 8. Distribution of back pain according to school-class and sex.

Table 4. Distribution of the number of pupils with and without back pain, according to sex.

	Back pain	No back pain	Total
Boys	16 (6%)	272	288
Girls	53 (18%) ^{x/}	248	301
Total	69 (12%)	520	589

^{x/} $p < 0.001$.

There were more pupils with back pain among those with postural faults than in the remaining material. Out of the 67 pupils with postural faults, 13 (19%) indicated back pain. Of the remaining 522 pupils, 56 (11%) had back complaints. The difference between the groups was significant, $p = 0.03$, (table 5).

Table 5. Distribution of the number of pupils with and without back pain, according to posture.

	Back pain	No back pain	Total
Postural fault	13 (19%) ^{x/}	54	67
No postural fault	56 (11%)	466	522
Total	69 (12%)	520	589

x/ $p = 0.03$

In a comparison between the sub-groups with various types of postural faults it was found that back pain was most common among pupils with postural fault type II, where 8 out of 36 pupils had indicated back pain. The remaining 5 pupils with back pain were evenly distributed in the other groups with postural faults. These groups are, however, too small to allow any definite conclusions to be drawn from these results.

b. Type of back pain, circumstances of occurrence

Of the 69 pupils, 16 boys and 53 girls, with back pain, out of the 589 subjects in the investigation, 27 pupils, (39%), indicated that they suffered back pain only in connection with physical activities. Twenty-two pupils, (32%), had pain only on sitting for extended periods, and 10 pupils, (15%), had pain both in connection with physical exercise and on extended sitting. The remaining 9 pupils experienced their back pain under different circumstances, (table 6).

There was no significant difference concerning the type and circumstances of occurrence of the pain between boys and girls, nor was there a difference correlated to age.

Table 6. Type and circumstances of occurrence of back pain.

At rest	5 pupils
In connection with physical activities	27
On extended sitting	22
Both at rest and in connection with physical activities	4
Both in connection with physical activities and on extended sitting	10
On all occasions mentioned	1

c. Pain in parts of the locomotor system other than the back

The questionnaire included questions concerning pain in parts of the locomotor system other than the back. There were 99 pupils,(17%), 47 boys and 52 girls, of the 589 pupils in the investigation who indicated that they were suffering, or had recently suffered, from pain in parts of the locomotor system other than the back. Fifty-five pupils,(56%), 31 boys and 24 girls, reported pain in the knee joints. The diagnosis given and the descriptions recorded concerning the characteristics of the pains were, with a few exceptions, Mb Schlatter and chondromalacia patellae. Pain in the knees was clearly dominant in the older age groups, (classes 7 and 9) where 34 of 51, and 14 of 26 pupils, respectively, reported this type of pain.

Pain in the feet, in particular due to flat-feet in combination with an aching sensation of tiredness, repeated sprains of the ankle joints and pain in the achilles tendon, was recorded by 21 pupils. These types of complaints were relatively evenly distributed among the various age groups, albeit with a certain predominance among the pupils in classes 1 and 4. There were more than twice as many girls as boys who indicated pain in the ankles and feet (29% compared with 13%).

Ten pupils reported pain in the hip joints, and 9 in the neck, in equal numbers of boys and girls. The remaining 4 pupils suffered from pain in more than one joint, (table 7).

Table 7. Pain in other parts of the locomotor system.

The neck	9 pupils
The hip joints	10
The knee joints	55
The ankle joints and/or the feet	21
Both hips and knees	2
Both knees and feet	2

On comparing the pupils in the postural fault group with the rest of the material it could be observed that there were significantly more pupils in the PF groups who had reported pain in parts of the locomotor system other than the back, $p < 0.05$. There were 16 (24%) out of the 67 pupils in the PF group, and 83 (16%) in the remainder of the material who indicated this type of pain.

d. Correlation between back pain and pain from other parts of the locomotor system

Of the whole material of 589 pupils, 28 (41%) of the 69 pupils with back pain, indicated that they suffered discomfort also from other parts of the locomotor system. There were 71 pupils, (14%), without back pain who had similar trouble in the locomotor system.

It can thus be seen that there were significantly more pupils who had pain in their back as well as in other parts of the body, $p < 0.001$, (table 8).

Table 8. Pupils with and without back pain compared with pupils with and without other pain in the locomotor system.

	No other pain	Other pain	Total
No back pain	449	71	520
Back pain	41	28 ^{x/}	69
Total	490	99	589

$x/ < 0.001$.

On dividing the material according to sex, it was observed that the significance applied to both boys and girls. There were 7 out of 16 boys, and 21 out of 53 girls with back pain as well as pain from other parts of the locomotor system.

On comparing the 67 pupils in the PF groups with the remainder in the total material it was observed that there were significantly more pupils in the PF group who had pain in the back as well as pain from other parts of the locomotor system, $p < 0.001$. Nine out of the 67 pupils in the PF group, (13%), and 19 of the rest of the material, (4%), indicated pain from the back as well as from other parts of the body.

e. Postural gymnastics

From the answers given in the questionnaire it was found that a total of 34 pupils, (6%), of the 589 pupils in the investigation had previously been given postural gymnastics. Twelve of these pupils were assessed in the class health examination as still having postural faults, and thus requiring further postural gymnastics. The remaining 22 pupils out of the 34 who had previously been given postural gymnastics were, in the class examination, judged to have no postural fault.

Thus, significantly more pupils in the PF group, (18%), than in the remaining material, (4%), had previously been given postural gymnastics, $p = 0.03$ (table 9).

Table 9. Comparison between assessment of posture and previously given postural gymnastics (PG).

	Previous PG	No previous PG	Total
Postural fault	12 x/	55	67
No postural fault	22	500	522
Total	34	555	589

x/ p = 0.03.

f. Subjective assessment of posture

From the answers in the questionnaire it was evident that 45 pupils, (8%), of the total material were considered by their parents or by themselves to have a faulty posture. Sixteen of these pupils were judged as having postural faults in the class health examination. The remaining 29 pupils who had considered themselves as having postural faults were, however, in the class examination assessed not to have a postural fault. It is worth noting that most of the pupils who had regarded themselves as having a faulty posture had previously been given postural gymnastics.

Further, there were a total of 51 pupils found, with postural faults in the class health examination, who did not regard themselves as having postural faults, (table 10).

Table 10. Comparison between assessment in the class examination and subjective assessment of posture.

	Subjective postural fault	Subjective no postural fault	Total
Postural fault	16	51	67
No postural fault	29	493	522
Total	45	544	589

DISCUSSION

In the present study school children in classes 1, 4, 7 and 9 (i.e. mean age 7, 11, 14 and 16 years, respectively), who took part in the routine health examination, composed the material.

For a study of this type the selection and variation with respect to age is quite satisfactory to give a representative picture of school children in different age groups. Children in the two lower age groups have, with only a few exceptions, not yet reached their puberal stage. In the seventh class most of the girls have passed the period of maximum growth rate, and the boys have just come into it (Willner 1972 and Rarick 1973). In the ninth class most of the girls have terminated their growth, while boys in general continue to grow for two or three years more.

Järnåkra School in Lund is representative for the whole town with regard to social structure. The town, however, is not representative for the whole country, as people with higher education are heavily over-represented here.

Definition and frequency of postural faults

The method used, when assessing the posture of the pupils, was to pick out those children, with that degree of postural fault, regarded as requiring postural gymnastics. Thus slight postural irregularities, like decreased kyphosis or a flat back only, were not considered as a postural fault.

After the definition of postural fault was decided upon, the school nurse showed a very good ability to pick out these children.

The present study, in its design with respect to material and methods can best be compared with investigations by Bang and Bojlén (1950) and Seyffarth (1972), and to some extent with studies by Arnesen et al. (1976) and Schellnack and Hähnel (1982).

Other investigations differ with respect to the population examined, concerning age, choice of sex and number of children or the methods used.

The method of assessing posture in this study, can best be compared to the classification of postural faults once set up by Staffel (1889) and later on used by Kirchoff (1893), Haglund (1923), Leger (1959), Matthiass (1966), Hähnel et al. (1981) and Schellnack and Hähnel (1982).

The way to describe different types of postural faults differs considerably from the classification of posture and postural faults according to the system introduced by the Department of Hygiene and Physical Education, Harvard University (1916).

This classification was later on used by Brown (1917), Fradd (1923), Bang and Bojlén (1950), Johansson (1953), Asmussen and Heebøll-Nielsen (1958), Heebøll-Nielsen (1958) and Maloney and Hildebrandt (1973).

With this classification, ranging from "excellent" to "very poor" it is very difficult to avoid aesthetic considerations of posture and body constitution.

Unbiased judgements are more easily achieved on the basis of strict descriptions of different types of postural faults.

However, what ever basis for classification is used, border-line cases will always be found, thus making the classification more difficult. In the present study attempts were made to define different types of postural faults, but subjects appeared having combinations of postural faults such as sway-back combined with an increased kyphosis.

Due to these factors mentioned, with respect to the assessment of posture, the frequency of postural faults in different investigations is extremely varying.

In the present study, comprising 589 school children between the ages of 7 and 16 years, there was a mean of 11% regarded as having postural faults.

The number of children with postural faults increased from about 4% in the first class to 16% in the ninth class. Children in classes 4 and 7 were found to have postural faults in 10% and 13% of cases, respectively, equally distributed between boys and girls in all age groups.

From a large orthopaedic screening of school children in the United States (Delaware) Cronis and Gleeson (1974) reported a total of about 13% as having postural faults. Watson (1975) found that 25-30% of Irish school children had serious postural defects. Fradd (1923) in his investigation found postural faults in about 30% of the subjects.

In contrast to this, Bang and Bojlén (1950) in Denmark reported postural faults in 75% of the school children examined, and Seyffarth (1972) reported postural faults in about 80% in Norwegian school children. It is interesting to observe that in the studies made by Seyffarth the 6-7 year-old children have the highest degree of postural faults of all children examined.

When considering this great number of postural faults in school children, one question inevitably arises:

Must there not be something wrong with a norm or classification when more than three quarters of school children between the ages of 7 and 16 are regarded as having a "faulty", "bad" or "poor" posture?

These different reports, covering many decades of our century, do point to the necessity of finding simple and useful definitions of postural faults, and, further, of finding methods for quantifying these postural faults.

Differences in leg length and structural scoliosis

In order to attain a more complete picture of the children examined, this study also comprises the children having differences in the length of their legs and the children having a structural scoliosis.

The length of the legs was examined with the child standing as described by Taillard and Morscher (1965) and recommended by, among others, Willner (1972) and Heufelder (1980). In the present study only differences of 5 mm or more were taken into account.

Twenty-six percent of the entire material had a difference in leg length, and of these, significantly more pupils belonged to the older age groups. There was almost the same number of children having a short leg in the group without postural faults as in the group regarded as having postural faults.

Ingelmark (1954) reported differences of leg length, exceeding 2 mm, in 70% of 10 year-old children. Cronis and Russel (1965) and Cronis and Gleeson (1974), on the other hand, reported a short leg in only 2 and 3%, respectively.

A short left leg was found in 70% by Ingelmark (1974). This value could be compared with results from, among others, Willner (1972) who reported a predominance of a short left leg in 68% of the younger age groups (between 6 and 13 years of age), while in the older age groups (14 to 19 years) the corresponding figure was 54%.

The same observations were made in the present study. In the younger age groups, i.e. 7 to 11 years, 63% had a short left leg, while in the 14 to 16 year-old children, 46% had a short left leg.

Twenty-one percent of the school children had a structural scoliosis of the magnitude described on page 26. The method used is a modification of the technique recommended by, among others, Willner (1972).

There were significantly more pupils in the older age groups having a structural scoliosis, 27% compared with 10%. Positive clinical findings (i.e. a positive forward-bending test) was reported by Willner and Willner (1982) in about 11% in the younger age groups and in about 20% in the 14 and 15 year-old children.

There are, however, some difficulties when trying to compare the frequency of structural scoliosis in different investigations, as many authors have not made a distinction between structural and functional scoliosis.

Winter (1975) revealed an incidence of structural scoliosis, of 5 degrees or more, according to Cobb, up to 12%, when screening children aged 10 to 14 years. Willner and Udén (1982) reported 2.8% of school children between 7 and 16 years having structural scoliosis of 5 degrees or more.

A positive correlation between postural faults and structural scoliosis has not previously been reported.

In the present study there were more children, in a statistically significant number, having a structural scoliosis as well as a postural fault.

Also it appeared that significantly more pupils had both a structural scoliosis and a difference in leg length. There was a good correlation between the side of the shorter leg and the side of the lower convexity of the scoliosis.

This has also been reported by Willner (1972). Mengé (1982), however, considers these two conditions to be independent of each other.

Results of the questionnaire

Back pain

As the questionnaire could not give a sufficiently detailed answer with respect to type and frequency of back pain, additional questions were put to the pupils in conjunction with the class health examination.

The purpose of this part of the investigation was mainly to illustrate the frequency of back pain in school children and not to penetrate the etiology of back pain by additional examinations with, for example, X-ray investigations.

As only about 5% of the cases had been referred to an orthopaedic specialist, most of the conditions were regarded as relatively slight.

There were 12% of the entire material who reported back complaints, and, of these, more than 95% indicated the lumbar spine as the site of the pain. About 85% of cases having low back pain was reported by Aukland et al. (1980).

There were, however, significantly more girls than boys with back pain, and the frequency increased strongly with increasing age. The 16-year-old girls reported back pain in 34%, and the boys in the same age group in 13% of the cases. As previously mentioned, girls with back pain in conjunction with menstruation were excluded.

There are only a few investigations in the literature where the frequency of back pain in school children has been reported. According to the Harvard classification of posture Brown (1917) found that 15% of the subjects with poor posture complained of back pain, while children without or with only slight postural faults had no back pain.

Burt (1949) claims that there is a significant relationship between faulty posture and low back pain, but gives no frequency numbers in his investigation. In addition to this he reports that pain in the limbs and in other parts of the back is often to be attributed to postural defects.

Of the children examined with some kind of postural fault or defect, including structural scoliosis and Scheuermann kyphosis, Engbaek (1974) found approximately 17% also to have back pain.

This is in conformity with the present study, where 19% of the children with postural faults reported back pain. This frequency is significantly higher as compared to those children in the entire material without postural faults (11%).

Girls with postural fault, type II, i.e. with an increased lordosis, often combined with a marked kyphosis as the most prominent features, complained of back pain to a greater extent than other pupils in the investigation.

The groups of different types of postural faults are, however, too small to allow any statistical conclusions to be drawn from these results.

Further, Engbaek (1974) considers that children with a bad prognosis with respect to back pain in later life are mainly those with a low Scheuermann kyphosis. Children with only a flat back do not run a greater risk than other children to contract back problems.

Bang and Bojlén (1950) are of the opinion that so-called "slumped" posture and postural faults with an increased lordosis will most likely give back problems in later life.

Willner (1977), Jorming (1979) and Kornfält (1981) point out that the question is not yet answered as to whether postural faults in children could give rise to back pain in adolescence or later in adult life.

Thus it seems evident that a longitudinal study of those children having postural faults would be of great importance in order to elucidate the prognosis of postural faults with regard to back pain.

Type of pain, circumstances of occurrence

Concerning back pain in children, there are investigations which point to the fact that extreme gymnastic exercises, especially on the élite level, could be responsible to back pain in children.

Oseid et al. (1974) found that 75% of Norwegian female athletes, mean age 15 years, suffered from back pain, and Wredmark et al. (1983) reported that 46.9% of 64 young female gymnasts, mean age 11.9 years, complained of stiffness after training and low back pain. In both of these investigations most of the girls having back pain also had increased lordosis. As previously mentioned, in the present study, there was also a correlation between low back pain and increased lordosis in girls.

It should be reiterated that, in the present study, the back problems complained of were regarded as fairly slight and that only about 5% of the children having back pain had been referred to an orthopaedic specialist. Further, there was no correlation between pain and gymnastics on an élite level in this study, as most of the children reported back pain in connection with both physical activities of any kind and on sitting for extended periods.

Pain in parts of the locomotor system other than the back

An interesting observation in the present study is that there were 17% of the children, as many boys as girls, who reported that they suffered from pain in parts of the locomotor system other than the back. Of these, 56%, mainly from the older age groups, reported pain in the knee joints, while 21%, more than twice as many girls, complained of various kinds of foot and ankle problems.

Ljunggren (1974), in conformity with the present study, found that approximately 12% of the children in classes 1, 4, 7 and 9 had symptoms in the locomotor system, and Köhler and Andersson (1978) reported that, out of 379 pupils consulting the school doctor, 23% had some kind of orthopaedic disorder. A higher incidence of knee and foot problems was reported by Cronis and Russel (1965) who, in an orthopaedic screening, found various kinds of knee and foot conditions in 41% of the school children.

These differences in frequency may be due to different criteria with respect to the degree and gravity of the pain problems chosen. Further, comparisons are difficult to make, as pain from the locomotor system including the total spine as well as the extremities, is most often reported under the same heading, for example: orthopaedic disorders or musculo-skeletal problems.

Correlation between back pain and pain from other parts of the locomotor system

In the present study it was found that symptoms from other parts of the locomotor system were significantly more frequent in pupils with low back pain. Further, this was significantly more often the case in children with postural faults.

This correlation could to some degree be due to faulty loading of the joints. For example, hyperextension of the knees is often seen in children with postural fault, type II, where increased lordosis is the most common feature.

Harms-Ringdahl (1981), points out that joints which are exposed to loading in their extreme range of motion for a longer period, often react with pain.

Further, children having postural faults may also have an impaired muscular control, which makes them more prone to incorrect loading of joint structures and to trauma.

One question arising is whether psychological factors of various kinds, make these children, having postural faults, more sensitive to smaller injuries and to pain problems, and further, whether their complaints are a way of communication in order to attract understanding and care.

Postural gymnastics and subjective assessment of posture

Concerning the subjective assessment of posture, given by the parents or by the children themselves, it was interesting to note that out of the 589 pupils in the investigation, 45 children, (8%), were considered by their parents or by themselves to have postural faults. Of these, 29 children, (64%), were judged to have a normal posture in the class examination. Almost every one of these children had previously been given postural gymnastics and was probably influenced by this fact.

On the other hand, 51 (76%) of the 67 pupils who were regarded as requiring postural gymnastics, did not regard themselves as having postural faults.

No other investigation has been found where the parents or the child himself has had the possibility to assess and give expression to, whether he has a faulty posture or not.

SUMMARY

The study comprised 589 school children in classes 1, 4, 7 and 9, corresponding to the mean ages 7, 11, 14 and 16 years, respectively, at Järnåkra School in Lund.

The aim of the study was to pick out children with postural faults regarded as requiring postural gymnastics, and further, to give a definition of the term "postural fault" to be practically used in school health care. The assessments of posture were made initially on 337 pupils by the school doctor, the school nurse and the author, independently.

The result of these assessments showed complete agreement in 75%. After the definition of postural faults was decided upon, the assessment of posture of the remaining pupils was carried out by the school nurse and the author only.

Out of the 589 pupils a mean of 11% was regarded as having a postural fault. The number of children with postural faults increased from 4% in the first class to 16% in the ninth class. The number of boys and girls having a postural fault was equal in all age groups.

Twenty-six percent of the 589 children had a difference in the length of their legs, exceeding 5 mm, and 21% had a structural scoliosis.

From a questionnaire, information of the frequency, type and occurrence of back pain was given, as well as on pain from parts of the locomotor system other than the back.

Twelve percent of the entire material reported back complaints, and of these more than 95% of the children indicated pain from the lumbar spine. Low back pain was most common in the 16 year-old girls.

Pain from parts of the locomotor system other than the back was reported by 17% of the children and the symptoms were significantly more frequent in pupils with back pain.

Back pain as well as pain from parts of the locomotor system other than the back was significantly more frequent in children with a postural fault.

Further, the opinion given by parents and the children themselves concerning the existence of a postural fault was reported.

II. COMPARISON BETWEEN DIRECT SUBJECTIVE ASSESSMENT OF POSTURE AND ASSESSMENT BY MEANS OF PHOTOGRAPHS, AND OBJECTIVE REGISTRATIONS BY MEANS OF SPINAL PANTOGRAPHY AND MOIRÉ TOPOGRAPHY.

This part of the study was carried out on 179 pupils, in approximately equal numbers from classes 6, 8 and 9, who were not involved in the other part of the investigation. There were 88 children, 48 boys and 43 girls, (mean age 14.7 years), regarded as having a postural fault, and 91 children, 41 boys and 47 girls (mean age 14.9 years) without postural faults.

The different measurements and recordings were carried out on the same day and in the following order:

1. Direct assessment of posture.
2. Spinal pantography.
3. Photography.
4. Moiré topography.

The direct assessments of the posture and the pantograph registrations were made by the author, while the photography and moiré topography was handled in an adjacent room by a photographer attached to the Hospital of Lund.

METHODS

In all registrations the pupils were instructed to stand in a relaxed and comfortable position, balancing equally on both feet, and looking straight ahead at eye level.

Assessment of posture

The assessment of posture was carried out using the same definitions as previously described, (pg.30).

Spinal pantography

The instrument described by Willner (1981) consists of a pantograph with a drawing table mounted on a tripod. At the end of the pantograph arm a low friction wheel is mounted (fig 9). The child stands in front of the pantograph in the same position as previously described.

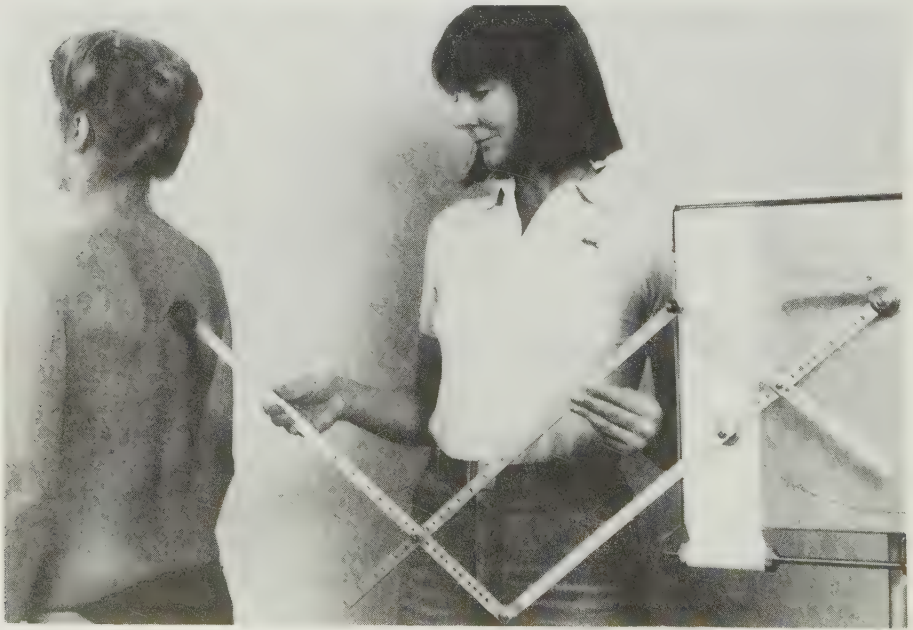


Fig. 9. The spinal pantograph.

By letting the pantograph wheel lightly follow the spinal processes from C7 to S1, the contour line of the thoracic kyphosis and the lumbar lordosis is registered on the paper roll on the drawing-table, reduced by 1:4.

By indicating C7 and S1 on the contour line on the paper, the height of the thoracic and lumbar spine can be measured. The ranges of the kyphosis and the lordosis are determined as follows: By allowing a ruler to follow the registered contour line of the spine and by marking the 3 tangents which deviate maximally from the vertical line, the angles of the thoracic kyphosis and lumbar lordosis can be measured, (fig. 10).

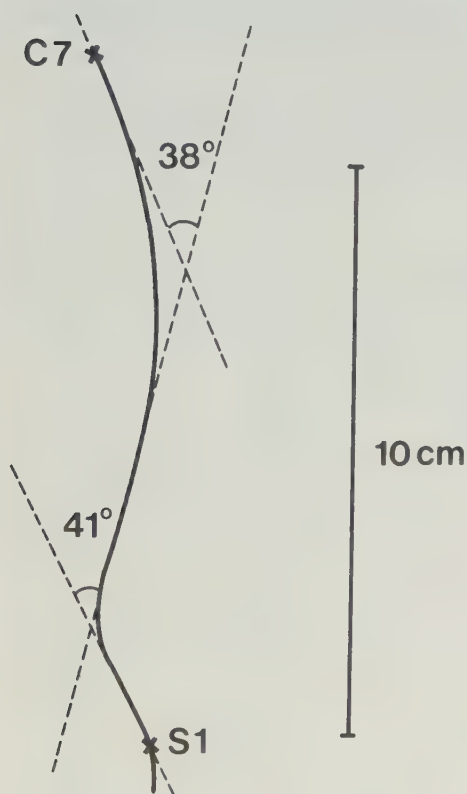


Fig.10. Method of recording the degrees of the thoracic kyphosis and lumbar lordosis.

The contour line on the paper also presents a possibility to study the anterior-posterior deviation of the trunk. By drawing a vertical line from the maximum point of the thoracic kyphosis, passing the indication of S1, the horizontal distance from S1 to the vertical line can be measured in mm, with sufficient accuracy.

Positive (posterior) and negative (anterior) deviation from 0 can be registered (fig. 11).

When the results are presented, the distance in mm from S1 to the vertical line is multiplied by 4 (as the reducing scale is 4) to make it easier to visualize the real values.

The reliability of the spinal pantograph measuring method has been documented by Willner (1981) and Willner and Johnsson (1983).

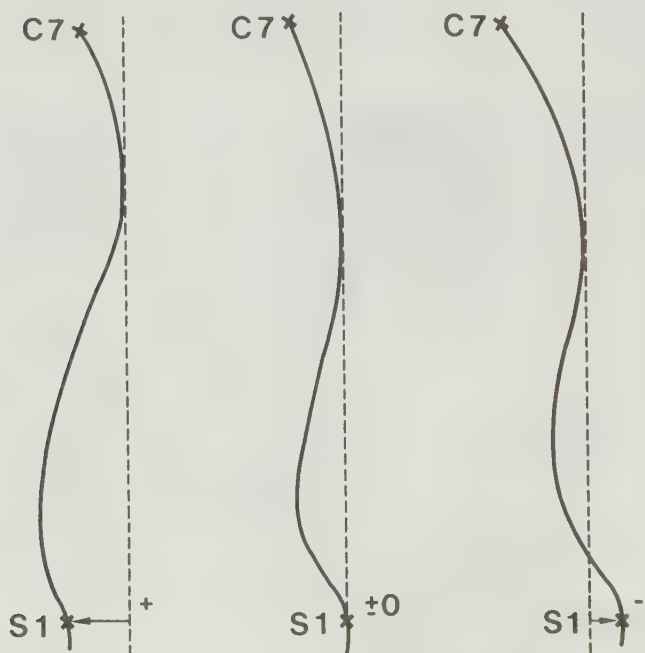


Fig. 11. Method of recording the anterior-posterior deviation of the trunk.

Photography

Only a side-view photograph was taken of each child. The child stood as previously described and with his arm on the camera side not covering any part of his back.

Moiré topography

These photographs were taken in the positions recommended by Willner (1979) i.e. with the back of the child just touching the moiré screen at the level of the scapulae and the buttocks, and with the camera and the light source at standardized distances from each other and from the moiré frame. The spinal process of C7 was marked on the skin before the moiré photography was carried out.

The ranges of the thoracic kyphosis and lumbar lordosis are determined as follows: The interval between two adjacent moiré fringes corresponds to 5.0 mm when the above conditions are adhered to.

The more contour lines on the moiré photograph, counted from C7 to the buttocks, the more pronounced are the curves of the spine in the sagittal plane.

The results of the spinal pantograph and those of the moiré photography are compared as follows: From the indication of C7 on the pantograph contour line, a vertical line is drawn passing the most prominent part of the thoracic kyphosis. The horizontal distance, "a" in the present study = kyphosis related to C7, here 12 mm (in reality 4.8 cm) corresponds on the moiré photograph to the 9 fringes from C7 to the top of the kyphosis, i.e. 4.5 cm (fig. 12).

In the same way comparisons can be made between the horizontal distance "b" = kyphosis related to lordosis, here 9 mm (3.6 cm) on the pantograph line, and the 6 fringes on the moiré photograph from the top of the kyphosis to the maximum depth of the lordosis (3.0 cm).

The horizontal distance "c" = lordosis related to S1, on the contour line of the pantograph, here 4 mm (1.6 cm) corresponds to the 3 lines, i.e. 1.5 cm on the moiré photograph.

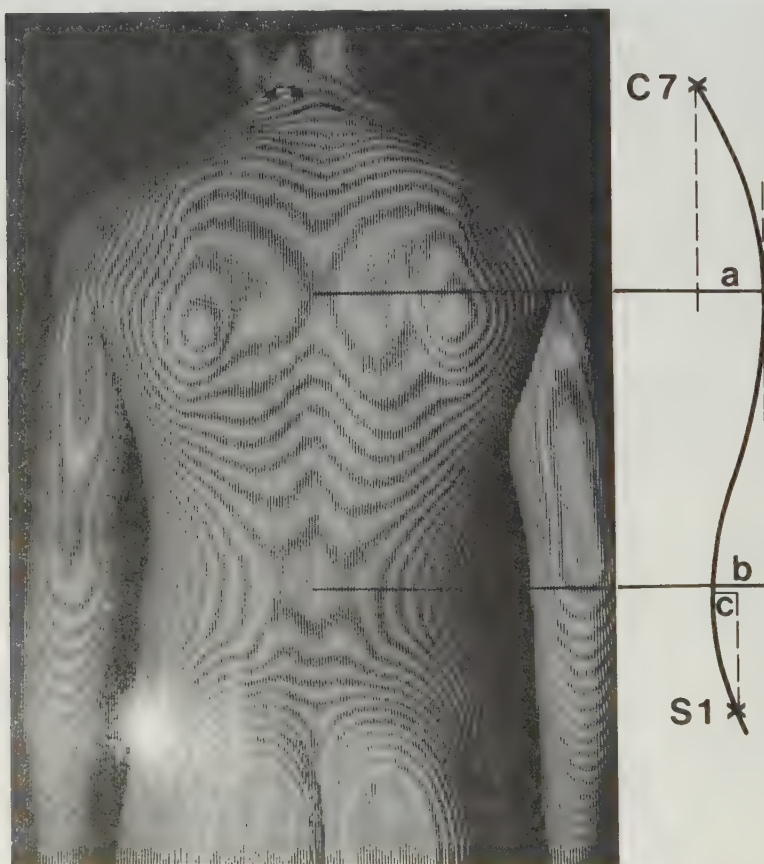


Fig. 12. Range of kyphosis and lordosis. A comparison between spinal pantography and moiré topography.

RESULTS

When assessing the posture of the 179 pupils comprising the material in this chapter, it was found that 9 pupils (3 girls and 6 boys) had what could be called a double or triple postural fault. The characteristic features of this posture were a marked sway-back, a pronounced kyphosis as well as an increased lordosis. In the results of this separate study, this specific type of postural fault will be referred to as type V (fig. 13).



Fig. 13. Postural fault
type V.

Comparison between the spinal pantograph measurements and direct subjective assessment of posture

a. Thoracic kyphosis and lumbar lordosis

The comparisons are given for each type of postural fault separately for the sake of clarity (table 11).

Normal group (i.e. without postural fault): These pupils had a mean value of the kyphosis of $30.6 \pm 5.6^\circ$, and this value was significantly different from those with postural faults type I, II and V ($p < 0.001$).

The mean value of the lordosis was $33.0 \pm 6.7^\circ$, which corresponded quite well to type I and III, but was significantly lower than those of type II ($p < 0.001$), IV ($p = 0.01$) and V ($p < 0.001$).

Type I: Definition: Increased kyphosis, normal lordosis.

The pantograph mean values ($41.6 \pm 4.0^\circ$ and $32.7 \pm 5.3^\circ$, respectively) corresponded very well to both the kyphosis and the lordosis in the subjective assessment, and differed significantly from the mean values of the kyphosis in the normal group ($p < 0.001$). Concerning the lordosis, the figures were almost equal.

Type II: Definition: Mainly increased lordosis, or a combination of an increased lordosis and kyphosis.

The mean values with respect to both the kyphosis ($36.8 \pm 8.5^\circ$) and the lordosis ($43.4 \pm 4.6^\circ$) was high, and they both differed significantly from those of the normal group ($p < 0.001$), and corresponded well to the subjective description of this type of postural fault.

Type III: Definition: "Sway-back", with the typical posterior deviation of the trunk, and a slightly increased kyphosis.

The mean value of the kyphosis was somewhat larger than that of the normal group, and the lordosis was of almost the same magnitude as the normal. There were, however, only 3 pupils in this group, for which reason any statistical conclusions should be avoided.

Type IV: Definition: Increased lordosis and flexion of the hip joints, normal kyphosis.

The mean value of the range of the lumbar lordosis was $42.0 \pm 11.3^{\circ}$, which corresponded to a significant difference from the lordosis of the pupils in the normal group ($p = 0.01$), and was of the same size as that of type II and V. The kyphosis, however, was of the same size as found in the normal group. The figures corresponded very well to the subjective assessment of type IV.

Type V: The "combined" postural fault type as previously described.

The mean value of the thoracic kyphosis was in this group of pupils the largest of all, ($48.0 \pm 8.4^{\circ}$) and the difference compared to the normal group was highly significant ($p < 0.001$). Also the mean value of the lordosis was one of the largest in the entire investigation, $43.2 \pm 8.7^{\circ}$ and differed significantly from that of the normal group ($p < 0.001$). These values were strongly suspected in the subjective assessment of the posture of these pupils.

Table 11. Spinal pantograph. Mean values, SD and range of kyphosis and lordosis in degrees.

	<u>n</u>	<u>Kyphosis</u>		<u>Lordosis</u>	
		<u>Mean</u>	<u>± SD</u>	<u>Mean</u>	<u>± SD</u>
					<u>Range</u>
No postural fault	91	30.6	± 5.6	33.0	± 6.7 (13-49)
Type I	18	41.6	± 4.0	32.7	± 5.3 (20-41)
Type II	54	36.8	± 8.5	43.4	± 4.6 (33-59)
Type III	3	35.0	± 4.4	30.7	± 3.2 (27-33)
Type IV	4	30.8	± 5.1	42.0	± 11.3 (33-58)
Type V	9	48.0	± 8.4	43.2	± 8.7 (26-54)

Table 12. Spinal pantograph. Anterior-posterior deviation, mean values, SD and range in cm.

	<u>n</u>	<u>Mean $\pm$ SD</u>	<u>Range</u>	<u>p</u> ^{*)}
No postural fault	91	-0.1 $\pm$ 1.4	-2.8 - 2.8	
Type I	18	1.3 $\pm$ 1.3	-0.8 - 3.6	< 0.001
Type II	54	0.5 $\pm$ 1.6	-3.6 - 5.2	0.03
Type III	3	2.3 $\pm$ 1.6	1.3 - 1.6	0.004
Type IV	4	-2.0 $\pm$ 1.3	-2.8 - 2.8	0.007
Type V	9	4.3 $\pm$ 1.0	2.8 - 5.6	< 0.001

*) comparison between the group without postural fault and type I-V.

b. Anterior-posterior deviation

There was a significant difference concerning the mean values of the "deviation" between the normal group and all types of postural faults. There was, however, a great variability in all groups and most of the groups were, as previously mentioned, too small to allow any statistical conclusions to be drawn from these results. It was, however, interesting to read the high mean values of type III and V, the two groups having a posterior deviation of the trunk as the most marked feature (table 12).

Comparison between spinal pantography and moiré topography, with regard to kyphosis and lordosis

There were, as described previously (in the section of methods) three possible comparisons to be made between the contour line of the spinal pantograph and the moiré photographs concerning the thoracic kyphosis and lumbar lordosis, (fig. 12);
a = kyphosis related to C7, b = kyphosis related to lordosis and c = lordosis related to S1.

As seen in table 13, the mean values of the three different levels a, b and c were greater when using the moiré technique. There was, however, quite a good correlation between the two methods with regard to the kyphosis (a) and the lordosis (c), $r = 0.79$. The correlation concerning kyphosis (b) was 0.52.

Of the 179 subjects 85 (48%) had larger values (difference > 0.5 cm), on the moiré photograph as compared to the spinal pantograph. Only 22 individuals (12%) had values which were larger on the pantograph.

There was, however, no statistically significant difference between different types of posture. The subjects most similar to the group without postural faults, concerning all levels, were those with postural fault, type II.

Table 13. Comparison between spinal pantography and moiré topography, with regard to kyphosis and lordosis. Mean values, SD and range in cm, n = 179.

	<u>Spinal pantography</u>		<u>Moiré topography</u>		<u>r</u>
	<u>Mean $\pm$ SD</u>	<u>Range</u>	<u>Mean $\pm$ SD</u>	<u>Range</u>	
Kyphosis related to C7 (a)	3.7 $\pm$ 0.10	0.8 - 8.4	4.0 $\pm$ 0.09	1.5 - 9.0	0.79
Kyphosis related to lordosis (b)	3.4 $\pm$ 0.11	0.4 - 8.4	4.0 $\pm$ 0.08	1.5 - 6.5	0.52
Lordosis related to S1 (c)	2.9 $\pm$ 0.07	0.4 - 6.4	3.1 $\pm$ 0.07	1.0 - 5.5	0.79

Comparison between subjective assessment of posture made directly and assessment from a side-view photograph

This comparison was carried out four months after the investigation was finished, in order not to be influenced by the results of the subjective assessments of the children's posture made directly.

In 163 out of the 179 cases, (91%), there was complete agreement between the two methods of assessing posture.

There was no difference in the results of the assessments with respect to different types of posture and the agreement was equally good concerning boys as girls, (table 14).

Further, the error of assessment seemed to be quite random, so that no systematic error with respect to the assessment was discerned.

Table 14. Comparison between subjective assessment of posture made directly (d) and assessment from a side-view photograph (p).

	No PF	I		II		III		IV		V		Total
	d p	d	p	d	p	d	p	d	p	d	p	
Boys	48 46	13	12	20	23	1	1	1	1	6	6	89
Girls	43 40	5	7	34	37	2	0	3	3	3	3	90
Total	91 86	18	19	54	60	3	1	4	4	9	9	179

PF = Postural Fault

I - V = types of postural faults.

DISCUSSION

The purpose of this part of the study on a group of 179 pupils aged 13, 15 and 16 years, was to compare the objective measurements by means of spinal pantography and moiré topography with the subjective assessment of posture, with respect to range of kyphosis and lordosis and the anterior-posterior deviation of the trunk. Further attention was given to the question whether a side-view photograph could be used when assessing posture.

This study shows that there is a good correlation between the objective values of the spinal pantograph and the subjective assessment of posture with respect to both kyphosis and lordosis as well as to the anterior-posterior deviation of the trunk.

In the literature, the range of normal kyphosis is considered to vary between 20 and 40 degrees.

These values were calculated by means of X-rays (Winter and Hall 1978, Fon et al. 1980 and Stagnara et al. 1982), kyphometer (Debrunner 1972 and Spangfort 1981) and inclinometer (Asmussen and Heebøll-Nielsen 1958). Timm (1971) reported values between 30 and 50 degrees in subjects between 2 and 20 years as measured with a curve ruler. Willner (1981) reported a mean of 40 degrees for the kyphosis in subjects, 10 to 19 years, using both the pantograph and X-rays. Menge (1982), using X-rays on adult subjects, found kyphosis in 75% to vary between 40 and 60 degrees.

In this study the mean value of the kyphosis in the group without postural fault was $30.6 \pm 5.6^{\circ}$ (range 13-41 $^{\circ}$). In the most divergent types of postural faults the kyphosis reached 65 degrees. The mean value for the whole material of 179 subjects was 37.1 degrees, a value which corresponds well with the investigations mentioned above.

The normal range of the lordosis is, in the literature, assumed to vary between 40 and 60 degrees, when measured on X-ray photographs (Willner 1981, Menge 1982 and Stagnara et al. 1982).

Using an inclinometer Asmussen and Heebøll-Nielsen (1958) reported a mean value of 21.6 degrees, and Willner (1981), using the spinal pantograph, got a mean value of 39.0 degrees.

The values, measured on X-ray photographs, are considerably higher than in the present study, (mean $33.0 \pm 6.7^\circ$, range 13-49 $^\circ$) in the group without postural faults, (reaching a maximum value of 59 degrees in the postural fault group, type II), but are similar to the values presented by Willner (1981) and by Willner and Johnsson (1983) where the mean value was 35.5 degrees for the same age group. The mean value of the lordosis for the total material of 179 subjects was 37.5 degrees.

A comparison of this type between subjective assessment of posture and objective registrations of posture and postural faults has not been presented before.

Suzuki et al. (1981) used the moiré technique for recording posture, as well as the degree of kyphosis and lordosis, but their calculations are different from those in the present study, so that direct comparisons are difficult to make.

Comparing the two methods, spinal pantography and moiré topography, the values found by the use of moiré photographs seem to be systematically too high.

This can possibly be a result of the technique used when taking the moiré photographs. The subject has to touch the moiré screen with both his scapulae and his buttocks, and may thereby increase the curves of his back.

The moiré technique, when used to register the curves of the spine in the sagittal plane, seems to be less practicable and even more complicated and time consuming than the registrations made by means of the spinal pantograph.

Both spinal pantography and moiré topography have, however, an advantage over the use of a kyphometer, as these two techniques can register exactly the level of the spine at

which the maxima of the kyphosis and lordosis are situated. The spinal pantograph also gives an exact "picture" of the anterior-posterior deviation of the trunk, which is a piece of information of great value when assessing posture and postural divergences.

Further, this study shows that posture can be evaluated with great accuracy from a side-view photograph. Photographs have often been used in other studies when assessing posture (Bang and Bojlén 1950, Fox 1951, Johansson 1953, Ingelmark 1954, Flint and Diehl 1961, Flint 1963, Arnesen et al. 1976, and Suzuki et al. 1981).

SUMMARY

This part of the study was carried out on 179 pupils, who were not involved in the other part of the investigation.

This study shows that it is possible, by means of a spinal pantograph, to verify the subjective assessment of posture with respect to the range of thoracic kyphosis and lordosis as well as the balance of the trunk.

Further, spinal pantography, when compared to moiré topography is both easier to handle and to make calculations from, and probably gives more correct values of the sagittal curves.

Both techniques, however, have a certain advantage, when compared with for example the kyphometer, in describing the level of the kyphosis and lordosis.

Further, this study confirms that a side-view photograph is a good "instrument" for the evaluation of posture and postural faults and quite comparable with subjective assessments of posture made directly.

III. DO CHILDREN WITH POSTURAL FAULTS DIFFER FROM A CONTROL GROUP WITH RESPECT TO PHYSICAL VARIABLES SUCH AS FLEXIBILITY OF THE SPINE, TRUNK MUSCLE STRENGTH, MUSCLE TIGHTNESS AND COORDINATION?

MATERIAL

The investigation in its second stage included the 67 pupils, 34 boys and 33 girls, who were regarded as having a postural fault and 67 matched controls, i.e. a total of 134 children.

The method to pick out the controls was to find a "twin" from the school-classes at Järnåkra School for every subject in the postural fault group with respect to sex, age, body height and body weight, but without postural fault, and who was willing to take part in the entire investigation.

The distribution of pupils both in the postural fault group and the control group, with respect to age and sex is shown in table 15.

Table 15. Distribution of the 134 pupils in the postural fault group (PF group) and the control group according to age and sex.

	Class 1 (mean age 7 years)	Class 4 (mean age 11 years)	Class 7 (mean age 14 years)	Class 9 (mean age 16 years)	Total
<u>Boys</u>					
PF group (Control group)	2 (2)	5 (5)	18 (18)	9 (9)	34 (34)
<u>Girls</u>					
PF group (Control group)	3 (3)	5 (5)	16 (16)	9 (9)	33 (33)
Total	5 (5)	10 (10)	34 (34)	18 (18)	67 (67)

The postural fault group, 67 pupils, had an average body height of 160.1 ± 14.4 cm (range 120-188 cm). The average body height for the 67 pupils in the control group was 160.2 ± 14.3 cm (range 122-185 cm). Further, there was no difference with respect to body height when the material was divided into different age-groups.

The average body weight for the pupils in the postural fault group was 47.8 ± 11.8 kg (range 24.3 - 75.4 kg), and for the control group 47.5 ± 11.6 kg (range 23.1 - 75.4 kg). There was a good agreement between the postural fault and control groups with regard to body weight also when the material was divided into different age groups.

The mean values concerning body height and body weight reported, correspond very well with the mean values for the entire material comprising 589 pupils. Thus, children with postural faults are not divergent from other children without postural faults with respect to body height and body weight.

In 21 (31%) of the children in the postural fault group there appeared a structural scoliosis. Of the children in the control group 16 (24%) had a structural scoliosis. This value is somewhat higher than the corresponding figures for the entire material (19%). The difference between the postural fault group and the control group with respect to the occurrence of structural scoliosis is, however, not significant, $p = 0.19$.

There were 13 pupils, (19%), (3 boys and 10 girls) in the postural fault group and 11 pupils, (16%), (5 boys and 6 girls) in the control group who reported back pain. The value for the control group is higher than the corresponding values for the entire material (11%). The difference between the postural fault group and the control group is not significant.

Concerning pain from parts of the locomotor system other than the back, 16 (24%) out of the 67 pupils in the postural fault group reported such complaints. Of the children in the control

group, 12 (18%) had pain in other parts of the locomotor system. The figures for the entire material was somewhat lower (16%). The difference between children with postural faults and the control group is not significant.

METHODS

Measurement of spinal forward flexion

The mobility of the spine was recorded by measuring the increase of the distance between C7 and S1 during maximum forward flexion, using a steel tape.

This method is a modification of the steel tape measuring method published by The American Academy of Orthopaedic Surgeons (1965).

Technique

The children were examined, standing in an upright, relaxed position, equally balanced on both feet, looking straight ahead.

The spinal process of C7 was determined as follows:

The spinal processes of C6 and C7 were palpated during a passive backward extension of the cervical spine. Normally C6 moves further into extension than does C7, thus as a rule making the spinal process of C7 more distinct to palpation. Furthermore, the spinal process of C7 is often more prominent than the adjacent spinal processes. The position of C7 was marked on the skin.

The spinal process of S1 was found as follows:

The posterior superior iliac spines (PSIS) were palpated on both sides from below, and then the two points were connected by a straight line. Another line was drawn along the spinal processes of the lumbar spine.

The intersection of these two lines indicates the spinal process of S1. Usually it is not necessary to draw these lines, as it is possible, with sufficient accuracy, to make a mark on the spinal process of S1 between and on a level with the two PSIS.

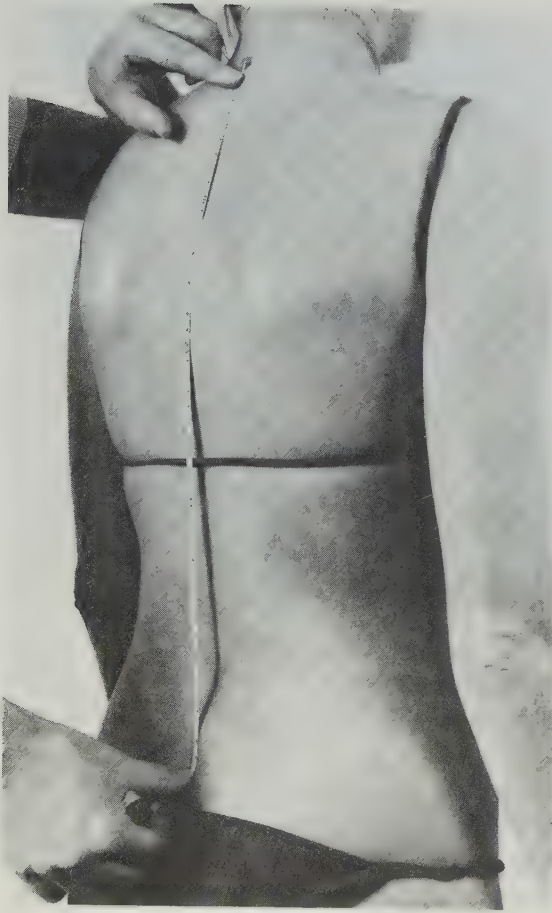


Fig. 14. Measurement of the distance C7-S1 in upright position.

With the child standing as previously described, the distance between C7 and S1 was recorded, (fig.14). Thereafter the child was asked to bend his head forward. By this flexion the mark on the spinal process of C7 is moved upwards. Another mark was made on the spinal process of C7, after which the child bent maximally forward (fig.15). The knees were permitted to be flexed during the forward flexion. The new figures on the steel tape were recorded.

The measurement was then repeated once. The highest value of forward flexion was recorded. Any back pain occasioned by the measurement was also recorded.

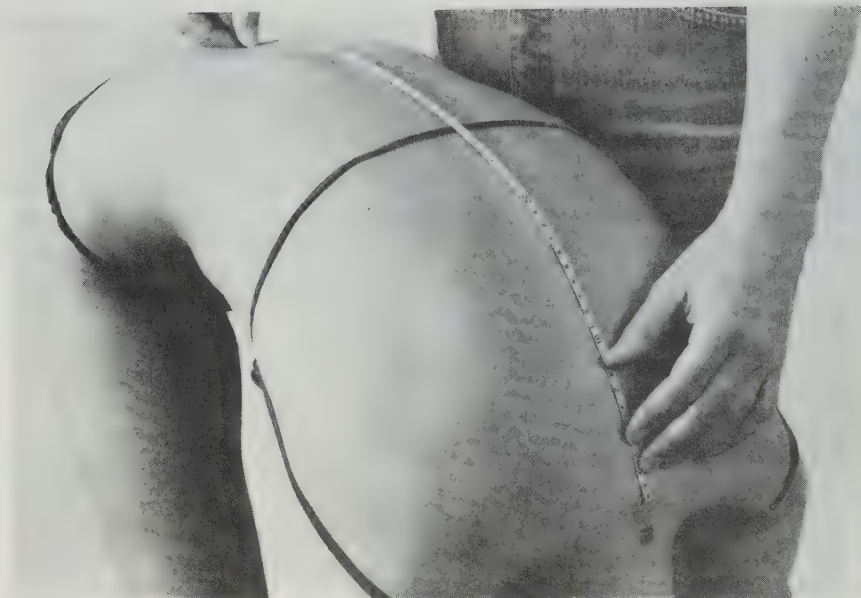


Fig. 15. Measurement of the distance C7-S1 in maximum forward flexion.

Reliability of the steel tape measuring method

The reliability of the steel tape measuring method has been tested. The measurement was performed twice, with an interval of one week, by the same observer, on 42 pupils in the third and the eighth classes.

The average of flexion lengthening was 8.0 cm on both occasions. The standard error of the two examinations was calculated to be 9 mm. This value corresponds to a coefficient of variation of 11%. Of the total 9 mm, 6.7 mm was due to the observer error, caused by, among other things, the difficulty in finding the accurate points for C7 and S1. The remaining error was due to the variability of the degree of forward flexion on the two occasions.

The coefficient of correlation was calculated to be 0.67.

Measurement of trunk muscle strength

The strength of the trunk flexors and the trunk extensors was measured, using a Salter balance, set up on wall bars.

The instrument was calibrated before and after the measurement of each group of 4-8 pupils. The frictional resistance of the measuring system varied between 8 and 12% of the applied force. This value has been added to the measured strengths.

Trunk flexion strength

The measurement of the strength of the forward flexors of the trunk was made in an upright position, with the back turned towards the wall bars (fig.16a). At the level of the buttocks a 6 cm-thick pad was placed. The strap from the recording instrument was placed around the chest and upper arms at the level of the attachment of the deltoid muscles. The test subject was asked to bend forward with his full force, without jerking.

The measurement was carefully standardized to permit comparisons. The subjects were told to do a trunk flexion and not a hip flexion and every movement during the test was supervised in detail.

The position of the feet in relation to the wall bars was also standardized.

The measurements were made on three successive contractions lasting at least 3 seconds, and with at least 15 seconds' interval between the measurements. If the force increased during the three trials, the measurements were repeated until a maximum was attained. The estimates were then made from the maximum values.

If the pupil experienced back pain, the measurements were discontinued if he so wished. If pain was experienced and the measurements were carried through, this fact was noted.

Trunk extension strength

The measurement of the strength of the trunk extensors was performed with the same method as used for the measurement of the trunk flexors, but with the test subject standing facing the wall bars (fig. 16 b).

For this measurement a 12 cm-thick pad was placed at the level of the pelvis. The strap from the instrument was placed around the chest and the upper arms at the same level as in the previous registrations.

The test subject was asked to bend backwards as strongly as possible without jerking and without raising his heels from the floor during the measurements. The measurements were carried out in the same way as described previously.

Reliability of the measuring method of muscle strength

An investigation as to the reproducibility of the method was first undertaken, for both the trunk flexors and the trunk extensors.

33 pupils were measured on two occasions with an interval of 6 months.

The error in the measurement of the strength of the trunk flexors, i.e. the variation among the three successive measurements was 28 and 38 N, for the first and second measurement, respectively. This corresponds to a coefficient of variation of 4% for both sets of measurements.

The corresponding values for the error in the measurement of the strength of the trunk extensors was 30 and 29 N, respectively. The coefficients of variation were thus 4% and 3% in the first and second measurements, respectively.

In conclusion it can be noted that there is good agreement among the three measurements on each occasion of measurement. The coefficient of correlation between the first and the second measurement was, for the trunk flexors 0.81 and for the trunk extensors 0.87.

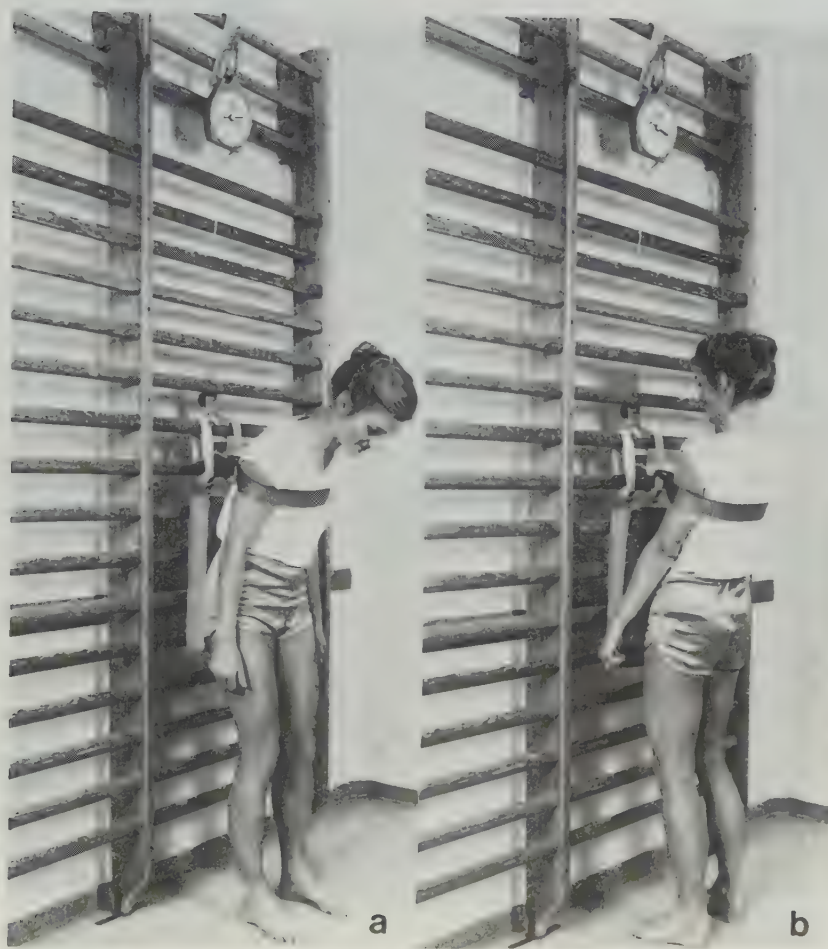


Fig. 16. Measurement of isometric trunk muscle strength.
a. trunk flexion and b. trunk extension.

Assessment of muscle tightness

The following muscle groups were tested regarding tightness:

1. Pectorals.
2. Hamstrings.
3. Hip flexors.

The technique for assessing muscle tightness as described by Janda (1975) has been used in the present study. This examination was made after testing coordination and muscle strength, so that the children by this time were somewhat warmed up.

The mobility of the hip and shoulder joints was examined before testing muscle tightness.

The figures 0, 1, 2 and 3 have been used to describe muscle tightness:

- 0 = Excessive range of motion.
- 1 = Normal muscle length.
- 2 = Moderate tightness.
- 3 = Pronounced tightness.

A light stretching force was applied in order to assess the end-feel. Any pain in connection with the examination was recorded.

The figures are defined as follows for the different muscle groups:

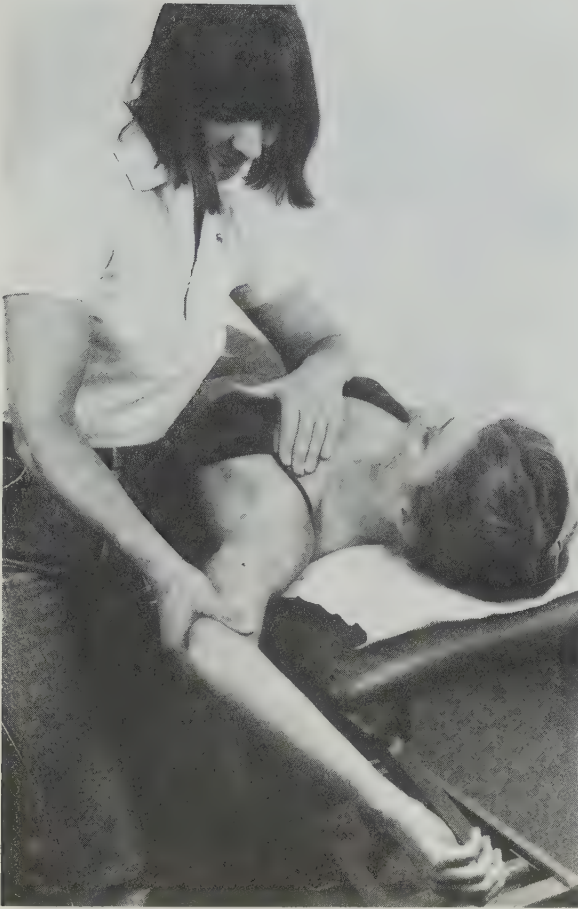


Fig. 17.
Assessment of
tightness of the
pectorals.

Pectorals (fig.17)

- 0 = Excessive range of motion = $> 10^{\circ}$ below the horizontal plane.
- 1 = Normal muscle length = the horizontal plane $\pm 10^{\circ}$.
- 2 = Moderate tightness = $10^{\circ} - 25^{\circ}$ above the horizontal plane.
- 3 = Pronounced tightness = $> 25^{\circ}$ above the horizontal plane.

The angle was estimated when the thorax started to move.

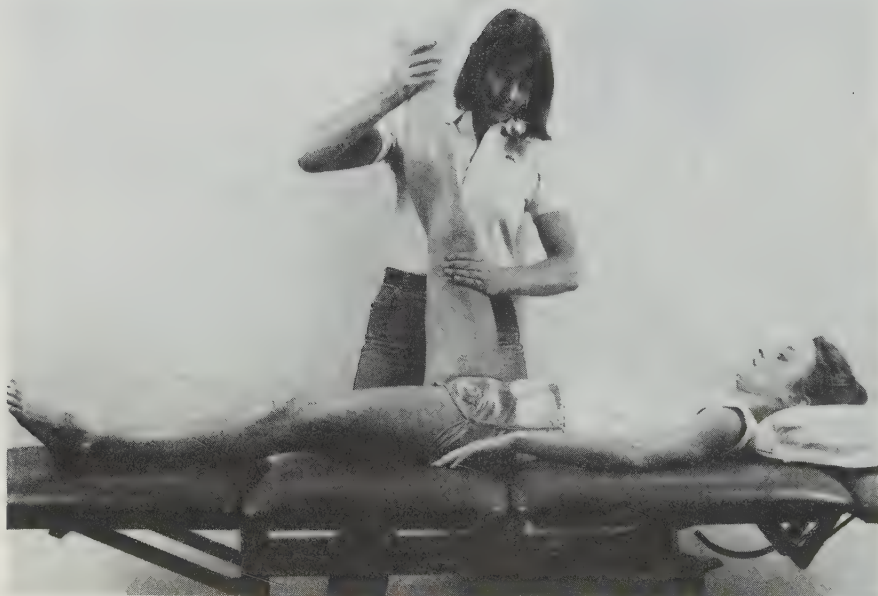


Fig. 18. Assessment of tightness of the hamstrings.

Hamstrings (fig. 18)

- 0 = Excessive range of motion = $> 90^{\circ}$.
- 1 = Normal muscle length = $75^{\circ} - 90^{\circ}$.
- 2 = Moderate tightness = $60^{\circ} - 75^{\circ}$.
- 3 = Pronounced tightness $< 60^{\circ}$.

The angle was estimated when the hamstring muscles had a tendency to flex the knee.



Fig. 19. Assessment of tightness of the hip flexors.

Hip flexors (fig. 19)

- 0 = Excessive range of motion = $> 10^{\circ}$ below the horizontal plane.
- 1 = Normal muscle length = the horizontal plane $\pm 10^{\circ}$.
- 2 = Moderate tightness = $10^{\circ} - 25^{\circ}$ above the horizontal plane.
- 3 = Pronounced tightness = $> 25^{\circ}$ above the horizontal plane.

The angle was estimated when a rotation of the pelvis could be noted.

Coordination tests

Coordination, i.e. the normal interplay between different groups of muscles, was investigated in two different ways. Coordination in motion and the coordination of simple arm and leg movements were tested with the help of rhythmic jumps. Static coordination was tested with the help of a balance test of standing on one foot.

Rhythmic jumps

The rhythmic jumps were demonstrated to the pupils, after which they were permitted to practice for about one minute before being tested. The type of jump used in the test is one of those most commonly used in school gymnastics. The rhythmic jumps were performed for about 20 seconds and were graded according to a three-point scale:

- 1 = Unable to perform the jump.
- 2 = Can perform the jump with difficulty.
- 3 = Can perform the jump without difficulty.

Balancing on one foot with closed eyes

The exercise was first demonstrated to the pupils. The pupils were then allowed, for about 1 minute, to try out on which foot they preferred to balance. Then, after having found their balance with their eyes open, and when they felt that they could stand stably, they were asked to close their eyes. Their arms were allowed to be used freely for balance adjustment.

The pupils were asked to remain standing on one foot with their eyes closed. They had not been given any prior information as to how long they were required to balance, only that they should keep their balance for as long as possible, or to discontinue when they were told to. Only one foot was tested.

The ability to balance was observed during a period of 30 seconds.

The balance test was graded in the same way as the rhythmic jumps:

- 1 = Unable to perform the test.
- 2 = Can perform the test with difficulty.
- 3 = Can perform the test Without difficulty

RESULTS

Spinal forward flexion

The postural fault group as a whole, now 66 pupils, (one pupil had left the school), had an average distance between C7 and S1 in the upright position of 44.0 ± 4.8 cm, (range 33.0 - 51.5 cm). The average value of the corresponding measurement for the 67 pupils in the control group was 44.0 ± 5.1 cm (range 32.0 - 52.0 cm).

On maximum forward flexion, the distance between C7 and S1 increased by 9.3 ± 1.5 cm (range 6.0 - 13.0 cm) for the PF group, which corresponds to an average percentage increase of 21.2%. The measurement in the control group showed an average increase (C7-S1) of 8.9 ± 1.4 cm (range 5.0 - 12.0 cm) corresponding to 20.3%.

The difference between the PF group and the control group was not significant. Furthermore, no significant difference became apparent when the material was divided according to sex, (table 16).

In a comparison between different postural faults, no significant difference in the capacity for maximum forward flexion was found when the pupils with postural fault of type II were compared with those having other types of postural faults. This sub-division and comparison has been chosen because, as has previously been mentioned, type II is the most common postural fault, and, being thus the largest group of the entire material, it could mask possible differences in flexion capacity among the various types of postural faults.

There was no difference concerning range of spinal forward flexion when children having back pain or who had recently suffered from back pain were compared with those who had not experienced pain in the back.

Table 16. Spinal forward flexion. Mean values, SD and range of the distance C7-S1 in an upright position and in maximum forward flexion in subjects with postural faults (PF) and in controls. Flexion is also given as a percentage of the distance C7-S1 in the upright position.

	<u>n</u>	<u>C7-S1(cm)</u>	<u>Range(cm)</u>	<u>Flexion(cm)</u>	<u>Range(cm)</u>	<u>Flexion %</u>
<u>PF group</u>						
Total	66	44.0 $\pm$ 4.8	33.0 - 51.5	9.3 $\pm$ 1.5	6.0 - 13.0	21.2
Boys	33	43.8 $\pm$ 4.5	35.0 - 51.5	9.4 $\pm$ 1.6	6.0 - 13.0	21.5
Girls	33	44.1 $\pm$ 5.1	33.0 - 51.5	9.3 $\pm$ 1.4	6.0 - 12.5	21.1
<u>Control group</u>						
Total	67	44.0 $\pm$ 5.1	32.0 - 52.0	8.9 $\pm$ 1.4	5.0 - 12.0	20.3
Boys	34	44.0 $\pm$ 5.0	32.5 - 52.0	9.1 $\pm$ 1.2	6.5 - 11.5	20.7
Girls	33	44.0 $\pm$ 5.1	32.0 - 51.5	8.8 $\pm$ 1.5	5.0 - 12.0	20.0

Spinal forward flexion in different age groups

In order to study the influence of age on the flexibility of the spine, a comparison between the pupils, of both sexes, in classes 3 and 8 (mean ages 10 and 15 years, respectively) was made (21 pupils from each class). These pupils did not participate in the other parts of the investigation.

The distance between C7 and S1 in the upright position was measured and found to be, on the average, 45.0 ± 2.5 cm (range 41.0 - 50.5 cm) among the pupils in class 8, and on the average 36.4 ± 2.0 cm (range 33.5 - 39.5 cm) among the pupils in class 3, i.e. the distance C7-S1 in the upright position was nearly 10 cm shorter than for class 8.

In a maximum forward flexion, the distance between C7 and S1 among pupils in class 8 increased on the average by 8.5 ± 0.9 cm (range 6.5 - 10.0 cm), which corresponds to an increase in this distance of 19%. The increase in the distance C7-S1 on forward flexion for pupils in class 3 was on the average 6.8 ± 1.1 cm (range 5.0 - 9.0 cm), corresponding to an increase of the distance by 18.7%, (table 17). These results show that the percentage increase in the distance C7-S1 in a maximum forward flexion is practically the same for both age groups, i.e. 19%.

Table 17. Spinal forward flexion in different age groups. Mean values, SD and range of the distance C7-S1 in the upright position and in maximum forward flexion. Flexion is also given as a percentage of the distance C7-S1 in the upright position.

	<u>n</u>	<u>C7-S1(cm)</u>	<u>Range(cm)</u>	<u>Flexion(cm)</u>	<u>Range(cm)</u>	<u>Flexion %</u>
Class 3 (mean age 10 years)	21	36.4 $\pm$ 2.0	33.5 - 39.5	6.8 $\pm$ 1.1	5.0 - 9.0	18.7
Class 8 (mean age 15 years)	21	45.0 $\pm$ 2.5	41.0 - 50.5	8.5 $\pm$ 0.9	6.5 -10.0	19.0

The percentage increase was, as previously shown, on the average, about 20% for the whole material of 133 pupils, whose length of spine varied between 32.0 and 52.0 cm. The increase in the distance between C7 and S1 in a maximum forward flexion for the total material is shown in figure 20.

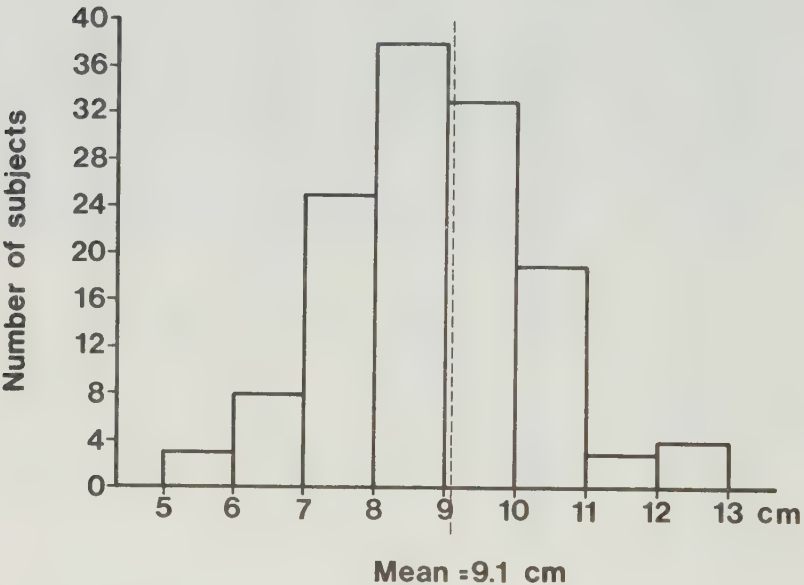


Fig. 20. Frequency distribution of the increase of the distance C7-S1 on maximum forward flexion of the spine, total material n = 133.

Thus, the decisive factor for the size of the increase in cm, in a maximum forward flexion of the spine, is not the age of the child, but rather the length of the spinal column.

Figure 21 shows the predicted value of flexion, in cm, on the assumption of an increase in the distance C7-S1 of 20%, for different values of the distance C7-S1 in the upright position.

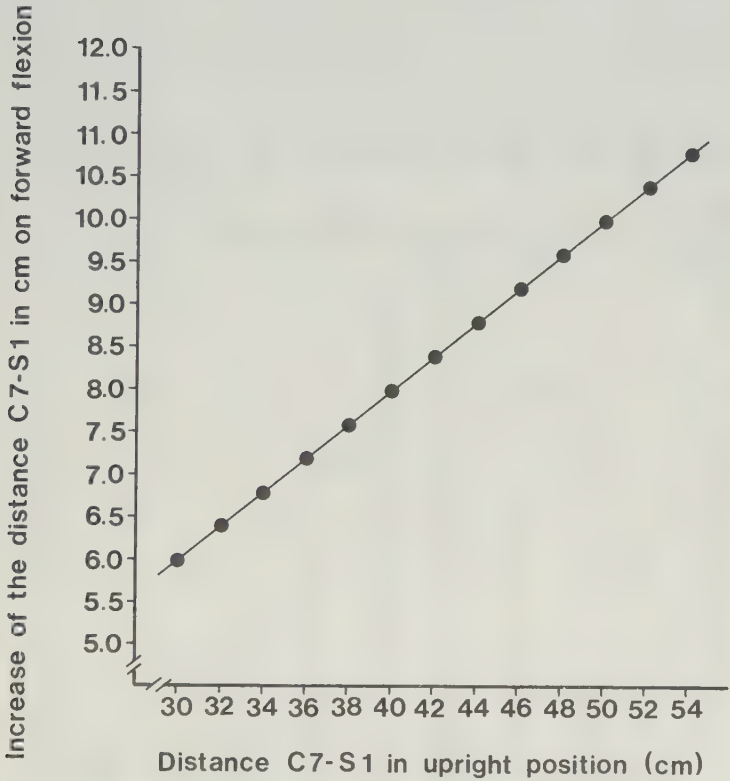


Fig. 21. Predicted value of forward flexion at a percentage increase of 20% for different values of the distance C7-S1 in upright position.

Trunk flexion strength

None of the 133 pupils had to or wished to discontinue the measurement of the trunk flexion strength due to pain or for other reasons.

The frequency distribution of trunk flexion strength for the total material is given in fig. 22. The strength of the trunk flexors in relation to body height given for boys and girls is shown in figs. 23 a and 23 b.

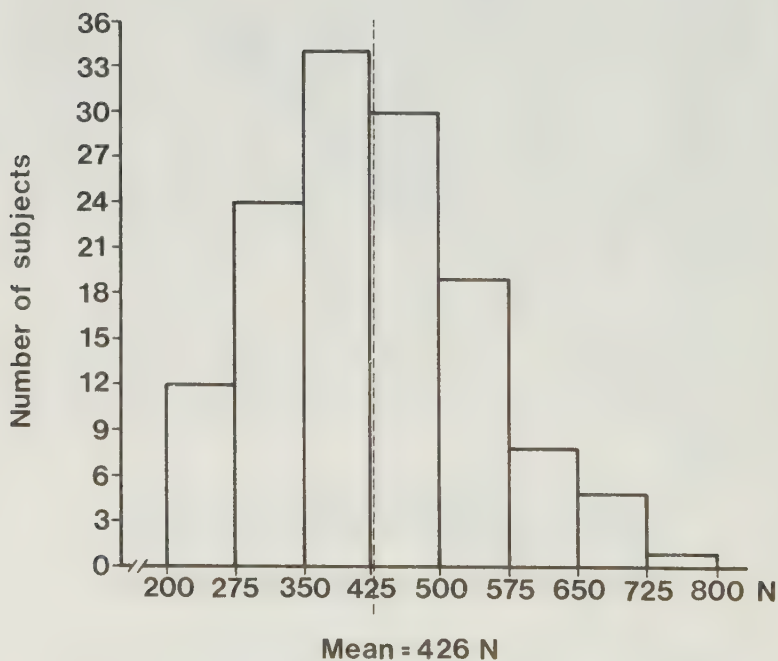
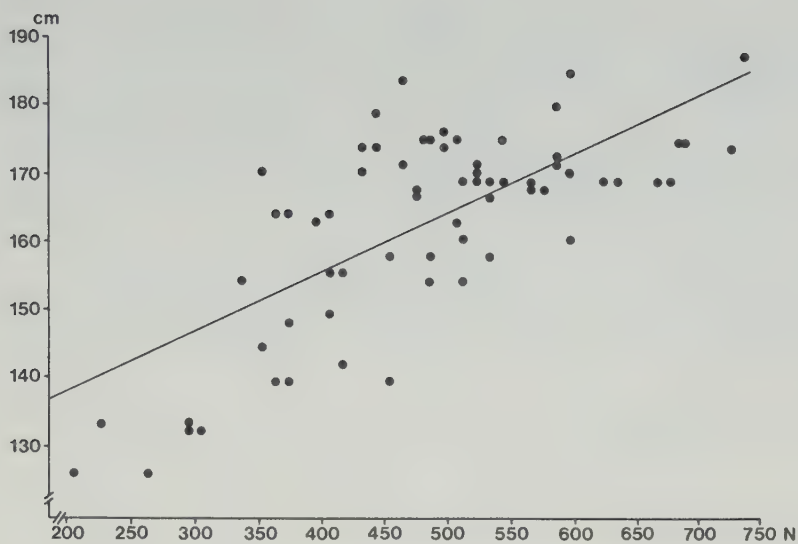
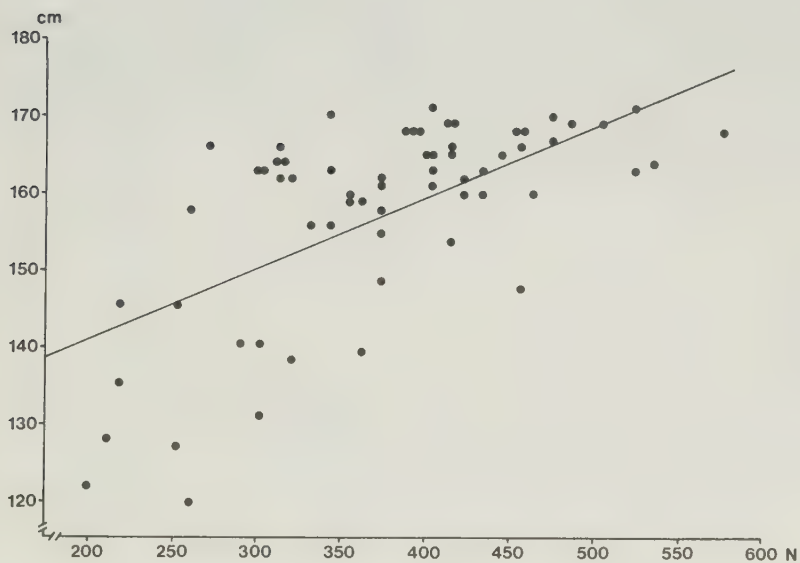


Fig. 22. Frequency distribution of trunk flexion strength, total material, $n = 133$.



$$r = 0.74.$$

Fig. 23 a. Trunk flexion strength in boys in relation to body height, $n = 67$.



$$r = 0.64.$$

Fig. 23 b. Trunk flexion strength in girls in relation to body height, $n = 66$.

The average trunk flexion strength for the group with postural faults, 66 pupils, was 404 ± 110 N (range 200 - 730 N). The average for the 67 pupils in the control group was 447 ± 116 N (range 200 - 720 N). The difference in trunk flexion strength between the two groups was significant, $p = 0.03$, as seen in table 18.

When the material was divided with respect to sex, the difference in trunk flexion strength between the PF group and the control group was found to be significant only in the case of girls, $p = 0.05$, (table 18).

The trunk flexion strength of the girls in the group with postural faults corresponded to approximately 77% of that for the boys, and the corresponding value for the control group was 78%.

When the material was divided according to the type of postural fault, no difference in the strength of the trunk flexors could be detected between the group with postural fault, type II and those with other postural faults. This sub-division and comparison has been chosen because, as has previously been mentioned, type II is the most common postural fault and thus, as the largest group of the material, it could mask possible differences in flexion strength among the various types of postural faults.

Trunk extension strength

None of the 133 pupils wished to discontinue the measurement of the trunk extensors due to pain or for other reasons. The frequency distribution of trunk extension strength for the total material is given in fig. 24. The strength of the trunk extensors in relation to body height given for boys and girls is shown in figs. 25a and 25b.

Table 18. Trunk flexion strength. Mean values in N, SD and range, in subjects with postural faults (PF) and in controls.

	<u>n</u>	<u>Mean $\pm$ SD</u>	<u>Range</u>	<u>P</u>
<u>PF group</u>				
Total	66	404 $\pm$ 110	200 - 730	0.03 x/
Boys	33	457 $\pm$ 114	200 - 730	0.11 xx/
Girls	33	351 $\pm$ 77	220 - 570	0.05 xx/
<u>Control group</u>				
Total	67	447 $\pm$ 116	200 - 720	
Boys	34	502 $\pm$ 117	260 - 720	
Girls	33	391 $\pm$ 85	200 - 530	

x/ Comparison between PF group and control group.

xx/ Comparison between boys and girls in PF group and control group.

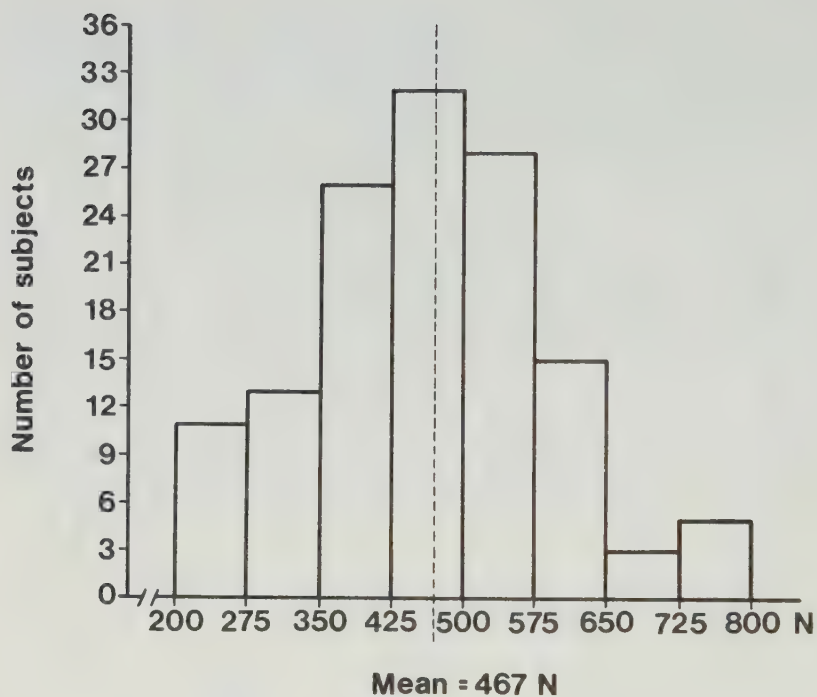
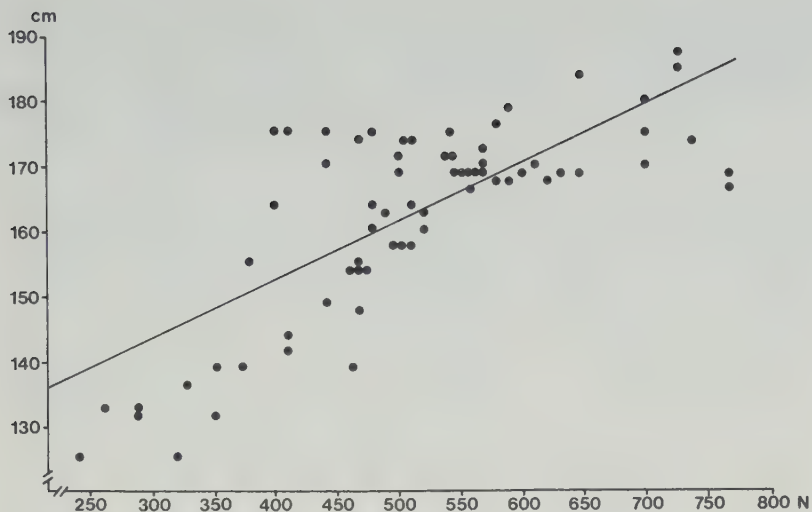


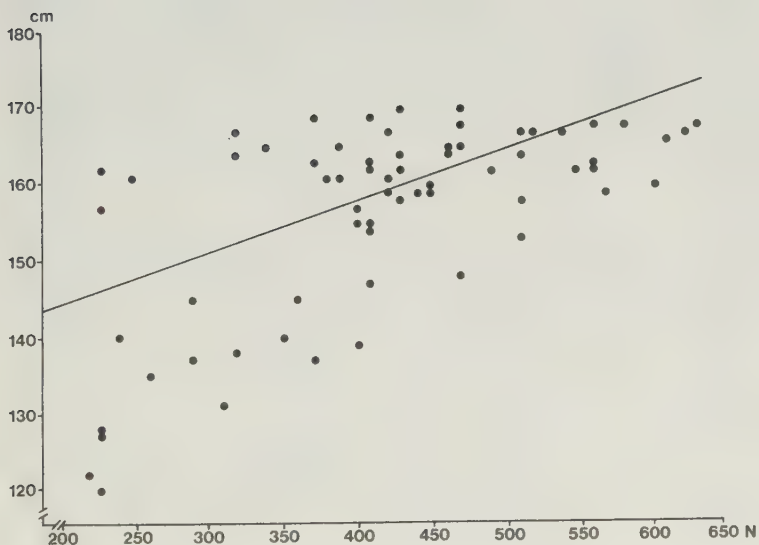
Fig. 24. Frequency distribution of trunk extension strength, total material $n = 133$.

The average value of the trunk extensors of the entire group with postural faults was 441 ± 119 N (range 230 - 730 N). The average value for the control group was 492 ± 126 N (range 220 - 770 N). The difference between the group with postural faults and the control group in trunk extension strength was significant, $p = 0.02$, as can be seen in table 19. On dividing the material according to sex, the difference between trunk extension strength was significant only for the girls, $p = 0.02$, (table 19).



$$r = 0.76.$$

Fig. 25 a. Trunk extension strength in boys in relation to body height, $n = 67$.



$$r = 0.63.$$

Fig. 25 b. Trunk extension strength in girls in relation to body height, $n = 66$.

Table 19. Trunk extension strength. Mean values in N, SD and range, in subjects with postural faults (PF) and in controls.

	<u>n</u>	<u>Mean ± SD</u>	<u>Range</u>	<u>P</u>
<u>PF group</u>				
Total	66	441 ± 119	230 - 730	0.02 x/
Boys	33	495 ± 109	240 - 730	0.17 xx/
Girls	33	386 ± 103	230 - 630	0.02 xx/
<u>Control group</u>				
Total	67	492 ± 126	220 - 770	
Boys	34	536 ± 135	290 - 770	
Girls	33	447 ± 107	220 - 620	

x/ Comparison between PF group and control group.

xx/ Comparison between boys and girls in PF group and control group.

The strength of the trunk extensors for the girls was about 78% of that for the boys in the group with postural faults, while in the control group the girls' trunk extension strength was 83% of that for the boys.

On dividing the group with postural faults according to type of postural fault no significant difference with respect to trunk extension strength between postural fault, type II, and the other types of postural faults could be demonstrated. Concerning the division according to different types of postural faults for the comparison of trunk extension strength, please refer to the commentary in connection with the presentation of the results for trunk flexion strength.

There was no difference concerning trunk muscle strength when children in classes 7 and 9 having back pain or who had recently suffered from back pain were compared with those who had not experienced back pain.

Extension/flexion - ratio

The ratio was determined by dividing the extension strength by the flexion strength for the postural fault group and the control group. The mean ratio was of almost equal magnitude for the two groups, and also when sub-divided with respect to sex and further, in comparisons between the two sexes.

The mean ratio for the postural fault group was 1.09 (boys 1.08 and girls 1.11). The ratio for the control group was 1.10, (boys 1.07 and girls 1.14). Furthermore, the extension/flexion-ratio was the same in all age groups.

The mean ratio for pupils with back pain was 1.08 and for those without back pain 1.10.

Muscular tightness

Muscular tightness was assessed of the following three groups of muscles: the pectorals, the hamstrings and the hip flexors on both sides of the body.

The assessment of the hamstrings and hip-flexors gave identical results for the right and the left sides of the body for all pupils investigated.

The pectoral muscles were generally more extensible on the right side for pupils in both the PF group and in the control group. There was a certain variation in the assessments concerning only grade 0 and 1 (0 = excessive range of motion, 1 = normal muscle length). In the assessment of the tightness of the right and the left sides, there was complete agreement in setting grades 2 and 3 (2 = moderate tightness, 3 = pronounced tightness). However, the difference in the tightness of the pectoral muscles between the right and left side was not statistically significant.

For this reason only the observations for the right side of the body will be given in the results.

Pectorals

No significant difference concerning the tightness of the pectoral muscles was noted between the PF group and the control group. The pectoral musculature of 35 of the 66 pupils in the PF group, and 44 of the 67 pupils in the control group was judged to have normal muscle length. There were 16 pupils in the PF group and 14 in the control group whose pectorals were judged to be somewhat more extensible than normal, and 15 pupils in the PF group, and 9 in the control group whose muscular tightness was moderate.

There were no pupils in either group whose pectoral musculature was judged to have pronounced tightness, (fig. 26).

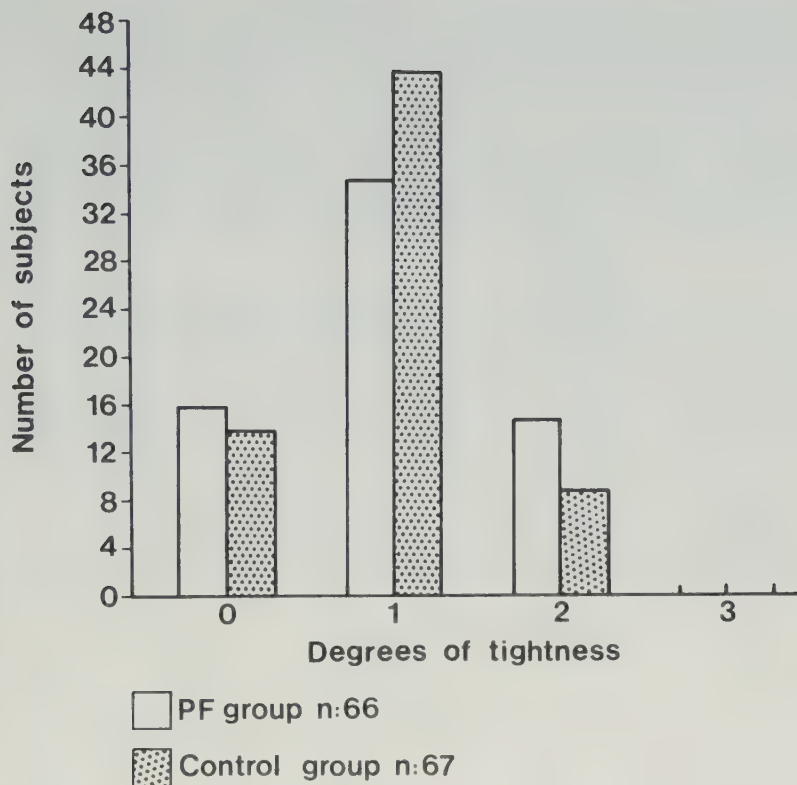


Fig. 26. Distribution of muscle tightness of the pectorals according to PF group and control group, $p = 0.27$.

0 = excessive range of motion

1 = normal muscle length

2 = moderate tightness

3 = pronounced tightness.

No statistically significant difference was noted between the PF group and the control group when the material was divided according to sex.

In general, the girls in both groups were found to have a somewhat greater extensibility in their pectoral muscles than the boys.

When the material was divided according to age, no statistically significant difference was found in the comparison either between the age groups or between the PF group and the control group within each age group.

A comparison between the boys and the girls in each age group showed that the boys in all age groups had somewhat tighter pectoral muscles than the girls.

Pupils with postural fault, type I, presenting a pronounced kyphosis and rounded shoulders, might be expected to have a shortening of their pectorals.

Six out of 13 pupils in this group had a tighter musculature than normal. The size of the group, however, is too small to make statements, concerning any significant difference among the various types of postural faults, possible.

The other PF groups did not deviate significantly from the control material.

Hamstrings

There was a significant difference between the PF group and the control group, as regards tightness of the hamstrings, $p = 0.02$.

Twenty-five of the 66 pupils in the PF group, and 32 of the 67 pupils in the control group, were judged to have normal length of the hamstrings. In the PF group there were 15 pupils, and in the control group only 4 pupils who had pronounced tightness of the hamstrings (fig. 27).

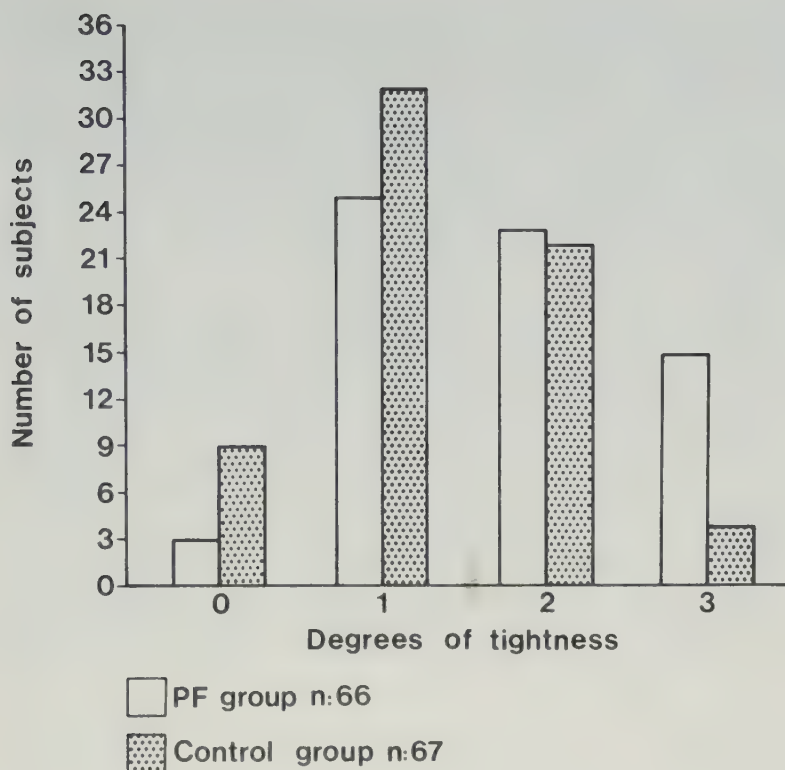


Fig. 27. Distribution of muscle tightness of the hamstrings according to PF group and control group, $p = 0.02$.

0 = excessive range of motion
 1 = normal muscle length
 2 = moderate tightness
 3 = pronounced tightness.

When the material was divided according to sex, it became apparent that the difference with respect to the tightness of the hamstrings between the groups was significant only for the boys, $p = 0.03$. However, the same tendency towards increased tightness of the hamstrings was noted among the girls in the postural fault group in comparison with the control group (table 20).

In the entire, undivided material, it was found that there was a statistically significant difference concerning muscular tightness between the boys and the girls. For instance, only girls were found to have above-normal extensibility and there were considerably fewer girls who were assessed to have pronounced tightness of the hamstrings, $p = 0.005$, in both the PF group and the control group (table 20).

On dividing the material according to age, no definite difference could be noted with respect to the comparative tightness of the hamstrings between the PF group and the control group, or when the division was made according to sex for the 30 pupils in classes 1 and 4. As regards the hamstrings of the pupils in classes 7 and 9, there were significantly more boys in the PF group who were found to have greater tightness than normal, $p = 0.05$, compared with the boys in the control group. The same tendency was found among the girls, but the difference between these groups was not statistically significant, (table 21).

In the comparison of muscular tightness of the hamstrings between the various types of postural faults all 8 pupils comprising the group with postural fault, type IV were judged to have tighter musculature than normal. The distribution of the degree of muscular tightness among the other different postural faults was relatively even.

Table 20. Distribution of muscle tightness of the hamstrings, according to postural fault group (PF) and control group. Degrees of tightness:

0 = excessive range of motion, 1 = normal muscle length,

2 = moderate tightness, 3 = pronounced tightness.

	<u>n</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>p</u>
<u>PF group</u>						
Total	66	3	25	23	15	x/ 0.02
Boys	33	0	7	16	10	xx/ 0.03
Girls	33	3	18	7	5	xx/ 0.12
						xxx/ 0.005
<u>Control group</u>						
Total	67	9	32	22	4	
Boys	34	0	16	15	3	
Girls	33	9	16	7	1	xxx/ 0.005
x/ Comparison between PF group and control group						
xx/ Comparison between boys and girls in PF group and control group						
xxx/ Comparison between boys and girls in the PF group and in the control group, respectively.						

Table 21. Distribution of muscle tightness of the hamstrings according to postural fault group (PF) and control group in different age groups. Degrees of tightness:

0 = excessive range of motion, 1 = normal muscle length,
2 = moderate tightness, 3 = pronounced tightness.

	<u>n</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>p</u>
<u>PF group</u> <u>classes 1 + 4</u>						
Total	15	0	7	6	2	0.17 x/
Boys	7	0	2	4	1	0.40 xx/
Girls	8	0	5	2	1	0.14 xx/
<u>Control group</u> <u>classes 1 + 4</u>						
Total	15	3	6	6	0	
Boys	7	0	4	4	0	
Girls	8	3	2	3	0	
<u>PF group</u> <u>classes 7 + 9</u>						
Total	51	3	18	17	13	0.07 x/
Boys	26	0	5	12	9	0.05 xx/
Girls	25	3	13	5	4	0.40 xx/
<u>Control group</u> <u>classes 7 + 9</u>						
Total	52	6	26	16	4	
Boys	27	0	12	12	3	
Girls	25	6	14	4	1	

x/ Comparison between PF group and control group

xx/ Comparison between boys and girls in PF group and control group.

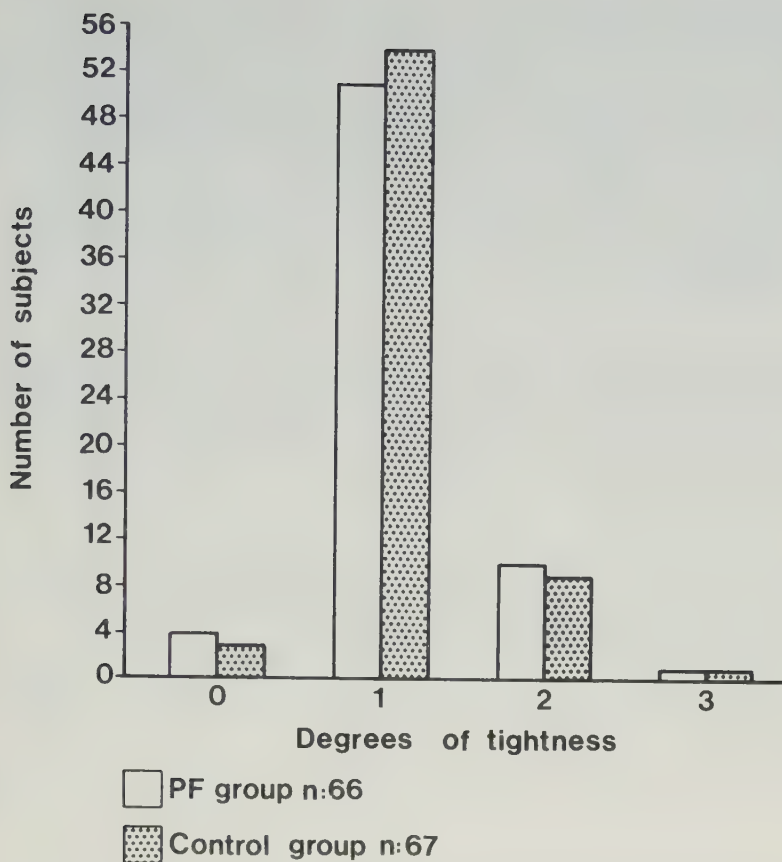


Fig. 28. Distribution of muscle tightness of the hip flexors, according to PF group and control group, $p = 0.96$.

- 0 = excessive range of motion
- 1 = normal muscle length
- 2 = moderate tightness
- 3 = pronounced tightness.

Hip flexors

The hip flexors of the majority of the pupils in both the postural fault group and in the control group were judged to be of normal length. There were only 11 of the 66 pupils in the PF group, and 10 of the 67 in the control group, who were identified as having moderate muscle tightness (fig. 28).

The two sexes in the PF group were found to be entirely comparable as regards the extensibility of their hip flexors, while in the control group, only two girls compared with 8 boys had hip flexors tighter than normal, and furthermore, all the pupils who were deemed to have an excessive range of motion were girls.

The difference between the boys and the girls was, however, not significant, $p = 0.08$.

When the material was divided according to age, the comparison between the PF group and the control group for each age group, showed no difference. Furthermore, no difference was found when the division was made according to sex and the groups were compared within each age group.

Pupils with postural fault, type IV, presenting an increased lordosis and flexion of the hip joints, might be expected to have a shortening of the hip flexors.

There was, however, no such difference concerning the tightness of the hip flexors between pupils having postural fault type IV and those with other postural faults.

There were only 7 out of the 133 pupils who were found to have tightness in all muscles tested. Nineteen pupils had muscle tightness in two of the three muscles tested. There were 57 pupils with normal muscle length or who had an excessive range of motion (fig. 29).

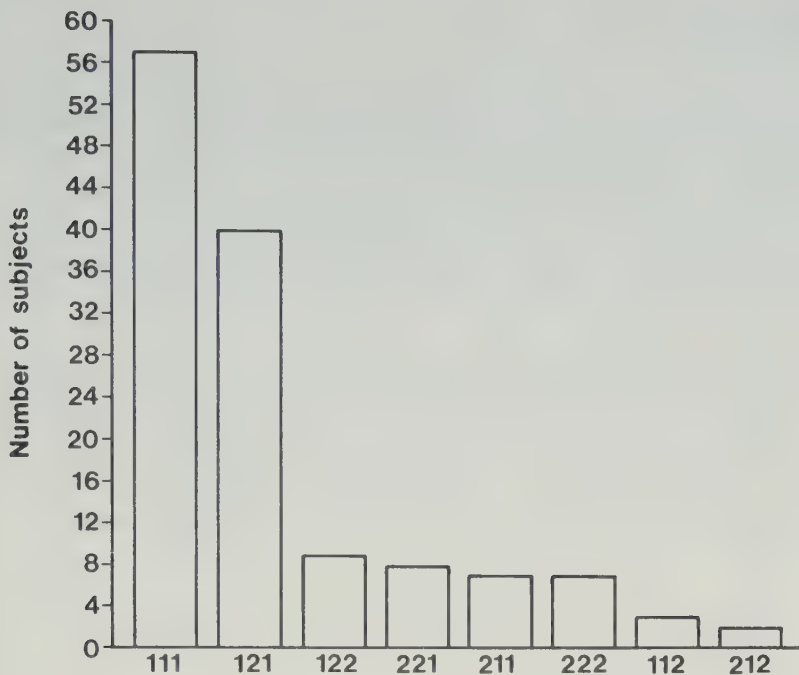


Fig. 29. The consecutive numbers in each set refer to degree of muscle tightness in pectorals, hamstrings and hip flexors, respectively, n = 133.

1 = excessive range of motion or normal muscle length
 2 = moderate or pronounced muscle tightness.

Coordination tests

In the report of the results, the two categories "can perform the jumps with difficulty" and "unable to perform the jump" have been combined, as the groups would otherwise be too small.

Rhythmic jumps

There were 9 out of the 66 pupils in the postural fault group who were unable to perform the rhythmic jumps without difficulty. In the control group of 67 pupils, 4 pupils could not do the rhythmic jumps satisfactorily. The difference between the PF group and the control group was not significant, $p = 0.14$. More boys than girls had difficulty in performing the test. The difference, however, was not significant, $p = 0.06$.

When the groups were divided with regard to age it was found that significantly more pupils in classes 1 and 4 had difficulty in performing the rhythmic jumps than in classes 7 and 9, $p < 0.01$. This applied to the classes as a whole, that is, not divided into postural fault group and control group.

Balancing on one foot

In the PF group, 28 pupils of 66, (42%), had difficulty in carrying out the balance test as compared to 8 of 67 pupils, (12%), in the control group. The difference between the PF group and the control group was significant, $p < 0.001$.

This also applied when the pupils were divided according to sex (table 22). No significant difference was observed between boys and girls within each group in their ability to carry out the test.

Further, the investigation showed that there was no significant difference in the pupils' ability to perform the balance test of standing on one foot, when the material was divided according to age groups, $p = 0.19$.

Table 22. Distribution of the ability to balance on one foot, according to postural fault group (PF) and control group.

	<u>n</u>	<u>Difficulties to perform the balance test</u>	<u>Can perform the balance test</u>	<u>p</u>
<u>PF group</u>				
Total	66	28	38	< 0.001 x/
Boys	33	14	19	0.01 xx/
Girls	33	14	19	0.002 xx/
<u>Control group</u>				
Total	67	8	59	
Boys	34	5	29	
Girls	33	3	30	
x/ Comparison between PF group and control group				
xx/ Comparison between boys and girls in PF group and control group.				

DISCUSSION

The main purpose of this part of the investigation was to study whether there are physical variables which can be regarded as responsible for maintaining a good posture or, where deficient, for contributing to the development of postural faults.

Impaired muscle strength and spinal mobility and muscle tightness are considered by many investigators (table 1) to be important factors in the development of postural faults. Coordination was found to be impaired in subjects with a structural scoliosis (Sahlstrand 1977) but this function has not been tested functionally in conjunction with an assessment of posture and postural faults.

Spinal forward flexion

Testing the mobility of the spine is regarded by many investigators as a necessity in the examination of an orthopaedic patient or when assessing postural defects. Different methods and devices have been used to measure, primarily, the sagittal mobility of the spine, i.e. flexion and extension.

The use of a steel or plastic tape measure as "one of the most accurate methods of estimating true spinal motion in flexion" was recommended by The American Academy of Orthopaedic Surgeons (1965). The method was originally described by Schober (1937) and has later been used by several authors (Dürrigél 1965, Macrae and Wright 1969, Moll and Wright 1971 and van Adrichem and van der Korst 1973).

The method used in the present study to determine the range of forward flexion of the thoraco-lumbar spine is a modification of the steel tape measuring method.

This method was chosen, mostly because of its handiness and its wide-spread use in physical therapy assessments. As postural defects appear mainly in the sagittal plane, a mobility test in this plane was chosen.

The reliability of the measuring method was tested initially on 42 pupils on two occasions with an interval of one week. The standard error of the two examinations was calculated to be 9 mm, which corresponds to a coefficient of variation of 11%. The coefficient of correlation was calculated to be 0.67. The difficulty with this method is, above all, to find the accurate point of C7, which already Schober (1937) pointed out as a weakness of the method.

In 1972 Debrunner presented his kyphometer, which instrument is a modification of Dunham's spondylometer (1949). This device was later used by Arnesen et al. (1976), Spangfort (1981) and Wredmark et al. (1983).

Reynolds (1975) compared three methods for measuring of spinal mobility, with special reference to ankylosing spondylitis, namely, the spondylometer, the goniometer and the tape measuring method. The spondylometer was found to be the quickest and simplest instrument to use, but its applicability is limited to spinal flexion and extension only. The tape measuring method was least satisfactory with respect to the reproducibility of the results. With the goniometer a greater variety of measurements could be made but was more time-consuming and sometimes uncomfortable for the patient.

There are, however, very few investigations in which the sagittal spinal mobility is correlated to posture, and in which attempts are made to study whether there appear any differences concerning spinal mobility when comparing children with and without a postural fault.

The results of the mobility test in the present study, using the steel tape measuring method, showed no significant differences between children having a postural fault and those without. Further, the range of mobility was as great in boys as in girls and independent of the type of postural fault and of back pain.

The percentage increase of the distance C7-S1 on maximum forward flexion varied in all age groups between 19% and 21%. These values correspond to an increase of about 8.0 to 9.0 cm when the thoraco-lumbar spine has a length of 45 cm. These results are in conformity with the average values for adults, given by Schober (1937) (6.0 to 9.0 cm) and by The American Academy of Orthopaedic Surgeons (1965) (about 10 cm).

One great advantage of this tape measuring method is, that, with the distance C7-S1 in an upright position known, it is possible to predict an expected "normal" value of spinal forward flexion and thus, easily to discover any deviations from normal mobility.

Trunk muscle strength

The strength of the trunk flexors and the trunk extensors, as well as the balance between these opposing muscle groups are paid particular attention in a few investigations concerning posture and postural faults.

In particular it is assumed that weakness of the abdominal muscles is the cause of certain types of postural faults, i.e. increased lordosis, faulty pelvic tilt or sway-back.

Horizontal positions, supine and prone, have mainly been used in the measurement of trunk muscle strength (Fox 1951, Flint and Diehl 1961, Flint 1963 and Arnesen et al. 1976). Mayer and Greenberg (1942) used the side-lying position when measuring trunk muscle strength.

In the present study the measurement of trunk flexors and trunk extensors was performed with the subject in an upright position, using a Salter balance set up on wall bars *) The technique used was a modification of the method described by, among

*) designed by the author in co-operation with Gunnar Persson, work instructor at the Department of Medical Rehabilitation, University Hospital, Lund.

others, Asmussen and Heebøll-Nielsen (1958). This measuring device was also used by Hemborg (1983).

The reliability of the measuring method was initially calculated on 33 pupils on two occasions with an interval of 6 months. The error in the measurement of the trunk flexors, i.e. the variation among the three successive measurements was 28 and 38 N on the two occasions. This corresponds to a coefficient of variation of 4% for both sets of measurements.

The corresponding values for the error in the measurement of trunk extensors were 30 and 29 N, respectively. The coefficient of variation was in the first measurement 4% and in the second 3%.

The coefficient of correlation between the two measurements was, for the trunk flexors 0.81 and for the trunk extensors 0.87.

According to Tornvall (1963), repeated measurements of trunk muscle strength may give rise to test values which might be due to a learning effect. He noted, however, that this rise first appeared after 6-7 examinations.

The muscles, mainly responsible for the development of trunk flexion and trunk extension strength are extensively described by Hemborg (1983). The importance of a standardization of a measurement technique and of the position of the test subject in order to get comparable results have been pointed out by Thorstensson and Nilsson (1982).

In the present study trunk muscle strength was significantly lower in the postural fault group than in the control group. There was, however, no difference with respect to the trunk muscle strength between children having different types of postural fault.

Boys were generally stronger than girls, and the trunk extension strength exceeded the strength of the trunk flexors. This is in conformity with results of other investigations (Mayer and Greenberg 1942, Asmussen and Heebøll-Nielsen 1958, Arnesen et al. 1976 and Aukland et al. 1980).

The values of trunk muscle strength in the present study show a good correlation with body height, especially in boys. The strength of the trunk flexors in the present study corresponds very well with the values reported by Asmussen et al. (1959), but are somewhat lower with respect to trunk extensors, especially in the younger age groups.

The extension/flexion-ratio was calculated and found to be equal for the postural fault group and the control group, 1.09 and 1.10, respectively. Further, there was no significant difference between boys and girls, with respect to age or to back pain, concerning the mean ratio.

These values correspond well with the mean ratio given for healthy adults, using the same technique (Hemborg 1983).

Muscular tightness

Muscular tightness, especially that of hip and shoulder joints has been regarded as an important factor in the development of postural faults (Bang and Bojlén 1950, Kendall and Kendall 1968 and Kendall et al. 1975).

In the present study tightness of the pectorals, the hamstrings and of the hip flexors was assessed. The methods used were modifications of the techniques according to Janda (1975). Goniometers have been used in studies for making exact measurements of the range of motion when muscular tightness is assessed (Ekstrand et al. 1982). Since the forces applied are not quantified the exactness is, however, not fully as accurate as reported.

Pectoral muscles are considered to be of normal length when the arms can be elevated to full-overhead in the sitting or the standing position, or, in the supine position with the back flat, when the arms can rest on the table above the head, (Bang and Bojlén 1950, Kendall and Kendall 1968, Seyffarth 1972 and Kendall et al. 1975). Janda (1975) prefers to test one arm at a time and judges the flexibility to be normal when the upper arm can reach the horizontal plane.

No significant difference concerning tightness of the pectorals was found between children in the postural fault group and the control group. The girls' muscles were in general found to be more extensible than the muscles of the boys in all age groups. As suspected, children with postural fault, type I, i.e. with an increased kyphosis and rounded shoulders as marked features, were found to have tightness of their pectorals to a greater extent than children with other types of postural fault.

Concerning hamstrings, the normal range of motion varies in different investigations between 80° and 90° in children as well as in adults. (Bang and Bojlén 1950, Phalen and Dixon 1961, Kraus 1963, Kendall and Kendall 1968, Sweetman et al. 1974, Janda 1975 and Kendall et al. 1975).

In the present study hamstring muscles were significantly shorter in children in the postural fault group compared with children in the control group. The tightness was most pronounced in the boys in the older age groups. An interesting observation concerning the tightness of the hamstrings was that all 8 children, with the postural fault, type IV, i.e. with an increased lumbar lordosis in combination with a flexed position of the hip joints, had short hamstring muscles.

The tightness of the hip flexors is mostly assessed with the test subject in the supine position with the opposite hip flexed maximally. The hip flexors are considered to have normal flexibility when the thigh of the tested leg can reach the horizontal plane (Bang and Bojlén 1950, Janda 1975 and Kendall et al. 1975).

The majority of the pupils were assessed as having hip flexors of normal length, and no significant difference was found between the postural fault group and the control group in any age group.

The children having a postural fault, type IV, with an increased lordosis and flexion of their hip joints, did not show short hip flexors to a greater extent than children with other types of postural faults. The statement by Kendall et al. (1975) that this position (posture) is combined with short hip flexors could thus not be confirmed in the present study.

It was interesting to note that only 7 out of 133 children had tightness of all muscles tested, and further, that it is unusual to have a normal or an excessive range of motion of the hamstring muscles and simultaneously to have tightness of the pectorals and the hip flexors. This appeared in only 10 out of 133 cases.

Coordination tests

Coordination tests have not been found in the literature in other investigations concerning posture and postural faults in children, except concerning structural scoliosis (Sahlstrand 1977).

The tests chosen in the present study were one dynamic, rhythmic jumps, and one static, balancing on one foot, with the eyes closed. The same degree of difficulty was chosen for all age groups.

There was no significant difference concerning the ability to perform the rhythmic jumps between children in the postural fault group and those in the control group. There were, however, significantly more pupils in the lower age groups than in the older age groups who were not able to perform the test satisfactorily ($p < 0.01$).

These results may confirm the view that different degrees of difficulty should be chosen according to the age of the child

tested. This is the case in the "Motor Impairment Test", designed by Stott, Moyes and Henderson (1972) where different degrees of difficulty are used in order to assess the level of motor function in children between the ages of 5 and 13 years. In the present study more boys than girls were unable to do the rhythmic jumps.

There were significantly more children in the postural fault group than in the control group who were not able to balance on one foot. In contrast to the results concerning rhythmic jumps there was found no significant difference with respect to this test between children in the different age groups or between boys and girls.

In a report by Gubbay (1975) the definition of the "clumsy child" was given, with its impaired ability to perform skilled movements, its lack of dexterity and body agility, despite normal intelligence and normal findings on conventional neurological examination. He found about 9% of children between the ages of 8 and 12 years having signs of clumsiness. The figures, however, are difficult to compare with the results from the present study, as the tests chosen are different. About 10% of the present material had difficulties to do the rhythmic jumps and about 27% were not able to balance on one foot. Kornfält and Köhler (1978) reported 6.7% of 10 year-old children having incoordination of fine and gross movements and 4.5% of the boys not being able to hop on one foot. Seyffarth (1972) assessed the coordination ability in children, without giving any frequency figures, mainly by having them rapidly pro- and supinate their forearms. He, however, recommends exercises for the improvement of balance and coordination of the children, such as standing on one foot while putting on and taking off their socks, at first with their eyes open and later on with their eyes closed.

SUMMARY

The aim of this part of the study was to investigate whether children with postural faults differ from a control group with respect to physical variables, such as spinal mobility, trunk muscle strength, muscle tightness and coordination (rhythmic jumps and balancing on one foot).

The trunk muscle strength and the ability to balance on one foot were defective, and the tightness of the hamstring muscles was more pronounced in the children in the postural fault group than in the control group. The difference was significant. Spinal mobility, tightness of the pectorals and the hip flexors and the ability to perform the rhythmic jumps, however, were found to be entirely comparable in the postural fault group and the control group.

IV. DO POSTURAL GYMNASTICS IN A SHORT-TERM FOLLOW-UP HAVE AN EFFECT ON POSTURAL FAULTS OR ON PHYSICAL VARIABLES, SUCH AS FLEXIBILITY OF THE SPINE, MUSCLE FUNCTION AND COORDINATION?

Thirty-five pupils, 17 boys and 18 girls, of the 65 pupils in the postural fault group were chosen at random to participate in the postural gymnastics.

The random selection was made by drawing lots in each class. The distribution of boys and girls was random, and if there were odd numbers of pupils having postural faults in any of the classes examined, the one pupil that was "supernumerary" was picked out to be included in the postural gymnastics group. For this reason there are four more pupils in the training group than in the remainder of the PF group.

The result of the random selection was 35 pupils in the training group and 31 in the remainder with even distribution in both groups with respect to age and sex.

Further, each type of postural fault was represented in both groups.

There were no significant differences between the pupils chosen at random for postural training and the remainder in the postural fault group with respect to body height and body weight, spinal forward flexion, trunk muscle strength, muscle tightness or coordination.

Six to 8 months after the first examination and after the period of postural training the posture of all pupils in the postural fault group and the control group was again assessed. In connection with this, spinal flexibility, trunk muscle strength, muscle tightness and coordination were re-examined.

There were now 129 pupils left, 65 belonging to the postural fault group and 64 to the control group. Five pupils had left school during the period of the investigation.

Performance of postural gymnastics

The school physiotherapist is in charge of the postural gymnastics and the training was carried out in exactly the same way as was previously used at Järnåkra School. The treatment is carried out during school hours 8 to 10 times, for a period of 3 to 4 weeks. The pupils come individually or in twos, if they want to, for sessions of about 20 minutes.

The instruction is planned for each pupil, and great importance is attached to the information in ergonomics, for example, correct sitting and working and in lifting and carrying techniques.

Depending on what type of postural fault the child has, and what is found in the examination with respect to mobility, muscle function or back pain, the children are given exercises to improve their ability to control and change the position of the pelvis, to strengthen trunk muscles lacking endurance and strength or to stretch short muscles, especially pectorals and hamstrings. Exercises to improve the spinal mobility are given mainly to children with an increased thoracic kyphosis, (appendix).

Further, each pupil receives an individual home training programme with the most important exercises and comments for his particular case. The exercises are to be done daily. After about a month or somewhat longer the children are rechecked by the school physiotherapist, in order to assess any changes or improvements in the childrens' condition, and to see whether the children are able to put their new knowledge, with respect to postural improvements and training, into practice.

Participation in postural gymnastics

Each child had the possibility to attend the postural exercises 9 times. None of the 35 pupils chosen at random were present at all 9 exercise sessions. Twenty-five of the children, (71%), partook 5 to 8 times, while the remaining 10 children were present one to 4 times. On the average the pupils participated in the postural gymnastics 5.1 times.

There was no significant difference between boys and girls with respect to their average number of attendences, but children in class 7 participated less than children in the other classes.

Concerning the attitude to postural gymnastics there were 22 of the 35 pupils, (63%), 9 boys and 13 girls, who were clearly positive towards this kind of postural training, and these pupils participated on an average 6.3 times. The remaining 13 pupils, 7 boys and 6 girls, whose attitude towards the training was more or less negative, partook in it on an average 2.8 times. Of these, 10 pupils belonged to class 7.

There was, however, no significant difference between boys and girls in any age group in their attitude to the postural gymnastics.

RESULTS

Re-assessment of posture

The assessment of the pupils' posture was made without knowing whether the children in the postural fault group had belonged to the training group or not. The pupils in the control group were also re-assessed.

There were only two girls, both in the ninth class, in the entire postural fault group who were judged not to have a postural fault in this second examination. One of them had attended the postural gymnastics only once and the other had been present 7 times. Both did voluntary physical activities, handball and gymnastics, respectively, and both had been given the mark "above average" by their gymnastics teacher.

There appeared, however two girls and one boy from the 7th class, belonging to the control group, who were judged as having postural faults at this re-assessment. The posture of all the other pupils, 63 from the postural fault group and 61 from the control group, remained practically unchanged.

Spinal forward flexion

No difference was found between the first and the second measurement in flexion capacity for either the postural fault group or in the control group. Neither was there a significant difference between the 2 groups as a whole, or when they were divided according to sex, in the distance between C7-S1 in the upright position, or in the increase of the distance on forward flexion.

The average distance C7-S1 in the upright position in the postural fault group (65 pupils) was measured and found to be 45.1 ± 4.4 cm (range 33.5 - 52.5 cm), and for the control group (64 pupils) 45.0 ± 4.4 cm (range 33.0 - 52.0 cm).

On maximum forward flexion, the distance C7-S1 increased for the postural fault group by an average of 9.3 ± 1.6 cm (range 6.0 - 13.0 cm), corresponding to a flexion increase of 20.5%. The measurement of maximum forward flexion for the control group gave an increase in the distance C7-S1 of 9.1 ± 1.1 cm, corresponding to a 20.2% increase.

Thus, there was good agreement in the distance between C7 and S1 in the upright position and in the increase of this distance on flexion of the columna, both between the two groups and between the measurements made on the two occasions, when account had been taken of the average increase in height in the period between the two measurements.

No significant difference in the distance on maximum forward flexion of the columna was found between the group chosen at random for physical training and the remainder of the postural fault group.

Trunk flexion strength

The trunk flexion strength of the PF group, 65 pupils, had increased since the first measurement by an average of 55 N, to a value of 459 ± 129 N (range 240 - 830 N). The strength of the control group, 64 pupils, had increased by 58 N to 505 ± 146 N (range 200 - 830 N).

Obviously the control group still had a higher value for the trunk flexors, but the difference in strength was no longer significant between the PF group and the control group, $p = 0.06$, as shown in table 23.

When the material was divided according to sex, no significant difference could be discerned between the groups either. The increase in trunk flexion strength from the first to the second measurement, was, for both groups as a whole, and also when divided according to sex, significant, $p < 0.001$ (table 23).

Again, no definite difference in trunk flexion strength showed up in a comparison between the pupils belonging to the groups with postural fault, type II and those with other types of postural faults.

The result of the trunk flexion measurement of the PF group showed no difference between the pupils who had exercised and those who had not.

Trunk extension strength

An increase of trunk extension strength of 40 N to 481 ± 128 N (range 180 - 780 N), was found in the 65 pupils with postural faults, while the average of the control group, 64 pupils, increased by 27 N to 518 ± 132 N (range 220 - 800 N).

Table 23. Trunk flexion strength. Mean values in N, SD and range on the two occasions, in subjects with postural faults (PF) and in controls.

<u>First measurement</u>			<u>Second measurement</u>							
<u>n</u>	<u>Mean</u>	<u>± SD</u>	<u>Range</u>	<u>n</u>	<u>Mean</u>	<u>± SD</u>	<u>p</u>	<u>Range</u>	<u>Diff</u>	<u>p</u>
<u>PF group</u>										
66	404	± 110	200-730	65	459	± 129	0.06	x/ 240-830	55	<0.001
33	457	± 114	200-730	32	523	± 135	0.16	xx/ 270-830	66	<0.001
33	351	± 77	220-570	33	397	± 85	0.13	xx/ 240-560	46	<0.001
<u>Control group</u>										
67	447	± 116	200-720	64	505	± 146		200-830	58	<0.001
34	502	± 117	260-720	33	574	± 153		280-830	72	<0.001
33	391	± 85	200-530	31	432	± 97		200-640	41	<0.001

x/	Comparison between PF group and control group
xx/	Comparison between boys and girls in PF group and control group
xxx/	Comparison between the first and the second measurement for the two groups.

Thus the pupils in the control group attained a somewhat smaller increase in trunk extension strength in the period between the measurements. No significant difference remained, therefore, with respect to the strength of the back muscles, between the PF group and the control group as a whole, $p = 0.10$. No definite difference could be seen between the groups when the material was divided according to sex, either, as shown in table 24.

The increase in trunk extension strength which had occurred in the time between the first and second measurement was significant for both groups as a whole and for both the girl- and boy- sub-group within the PF group. In the control group, however, the increase was significant only for the boys, (table 24).

The comparison of trunk extension strength between the pupils with postural fault, type II, and those with other types of postural faults, again showed up no definite difference between these groups in the second measurement. The increase in strength was highly significant for all boys, but could be ascertained only in the girls with postural fault, type II.

A comparison of the trunk extension strength between pupils with postural fault who had participated in the physical training and those who had not, did not show a significant difference after the period of training.

Both groups as a whole showed an increased strength of the trunk extensors, on an average of 40 N, and the increase was significant also when the material was divided according to sex, for all boys within both groups of postural faults, and for the girls in the exercising group.

Table 24. Trunk extension strength. Mean values in N, SD and range on the two occasions, in subjects with postural faults (PF) and in controls.

	<u>First measurement</u>			<u>Second measurement</u>			<u>Diff</u>	<u>p</u>
	<u>n</u>	<u>Mean</u>	<u>+ SD</u>	<u>n</u>	<u>Mean</u>	<u>+ SD</u>		
<u>PF group</u>								
Total	66	441	+ 119	65	481	+ 128	40	<0.001 xxx/
Boys	33	495	+ 109	32	543	+ 126	48	<0.001
Girls	33	386	+ 103	33	419	+ 97	32	0.001
<u>Control group</u>								
Total	67	492	+ 126	64	518	+ 132	27	0.002 xxx/
Boys	34	536	+ 135	33	578	+ 132	42	0.001
Girls	33	447	+ 107	31	451	+ 99	4	0.56

x/ Comparison between PF group and control group

xx/ Comparison between boys and girls in PF group and control group

xxx/ Comparison between the first and the second measurement for the two groups.

Muscular tightness

Pectorals

There was a somewhat larger number of pupils, particularly in the postural fault group, whose pectoral muscles were estimated to be more extensible in the second measurement when compared with the first measurement. However, there was still no significant difference either between the PF and the control groups, as a whole, or when the material was divided according to sex, or in the comparison between the first and the second measurement.

In the second measurement the extensibility of the pectorals was significantly greater for the girls than for the boys in the PF group, $p = 0.05$. This difference between boys and girls was less marked in the control group.

In the comparison between the group of pupils chosen at random from the PF group to partake in exercises, and the remainder of the PF group, a significant difference was found between the two groups, in the extensibility of the pectoral musculature after the period of physical training, $p = 0.01$. The results of the second measurements on the tightness of the pectoral musculature for the group which had not partaken in the exercises, were unchanged since the first measurement. The exercised group, on the other hand, had both fewer pupils with tightness of the pectoral muscles, and an increased number of individuals with greater extensibility of the musculature.

On dividing the two groups according to sex, the difference between the exercised and the un-exercised sub-groups was significant only for the boys, $p = 0.03$.

Hamstrings

The results concerning the tightness of the hamstrings in both the PF group and the control group were very similar to those of the first examination. Thus, it was still the pupils in the PF group whose muscular tightness was considerably greater than those in the control group, and this difference remained significant, $p < 0.01$ (table 25).

A significant difference in the muscular tightness was now observed also among the girls when the material was divided according to sex, and not, as in the first measurements, only among the boys.

However, there were still more boys than girls in both groups who were judged to have tight hamstrings, and it was still only among the girls that an excessive range of motion in the hamstrings was observed. The difference in this tightness between the sexes was significant in both the PF group and in the control group (table 25).

On dividing the material into age groups, the second measurements gave practically the same results as the first, for the younger age groups. Thus, there was still no difference between the PF groups and the control group, and the tendency towards increased tightness among the boys as compared with the girls, remained.

In the older age groups there appeared in the second measurement a significant difference between the PF group and the control group as a whole, $p = 0.03$, with respect to tightness. Both boys and girls in the PF group were found to have greater tightness than those in the control group.

Table 25. Distribution of muscle tightness of the hamstrings, according to postural fault group (PF) and control group. Degrees of tightness:
 0 = excessive range of motion, 1 = normal muscle length,
 2 = moderate tightness, 3 = pronounced tightness.

	<u>First examination</u>					<u>Second examination</u>					<u>P</u>
	<u>n</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>n</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	
<u>PF group</u>											
Total	66	3	25	23	15	65	3	22	24	16	0.004 x/
Boys	33	0	7	16	10	32	0	7	14	11	0.02 xx/
Girls	33	3	18	7	5	33	3	15	10	5	0.04 xx/
											0.03 xxx/
<u>Control group</u>											
Total	67	9	32	22	4	64	8	32	21	3	
Boys	34	0	16	15	3	33	0	15	15	3	
Girls	33	9	16	7	1	31	8	17	6	0	0.002 xxx/

x/ Comparison between PF group and control group
 xx/ Comparison between boys and girls in PF group and control group
 xxx/ Comparison between boys and girls in the PF group and in the control group, respectively.

In a comparison of the tightness of the hamstrings in the second measurements, i.e. after the physical exercises, it was observed that, in the boys in the group that had exercised, the tightness of the hamstrings had decreased, while, during the same period, the hamstrings of the boys who had not exercised had increased somewhat in tightness.

The difference in tightness between the boys of the two groups was significant, $p = 0.01$. Similar tendencies towards such changes in muscular tightness among the girls could not be noted.

Hip flexors

No difference became apparent after the second measurement either, concerning the extensibility of the hip flexors in a comparison between the PF group and the control group.

In the PF group, there were now somewhat more boys in classes 7 and 9 who were judged to have tighter hip flexors, but the difference between the boys and the girls was not significant, $p = 0.08$. In the control group no change had occurred in the tightness of the hip flexors among either the boys or the girls, so that the difference found in the first measurement, i.e. more boys than girls with tight hip flexors, remained unaltered. The difference between the sexes was, however not significant in the control group either, $p = 0.06$.

Further, no difference was observed with respect to tightness of the hip flexors between the exercised as compared with the unexercised pupils within the PF group.

Coordination tests

Rhythmic jumps

Only 3 pupils in each group were unable to perform the test satisfactorily at the time of the second examination, as compared to 9 in the PF group and 4 in the control group on the first occasion. Those of the PF group who had improved were equally distributed among the trained and the untrained group.

Four out of the 6 pupils who were unable to perform the test belonged to the older age groups.

Balancing on one foot

In the second examination there was still a significant difference between the PF group and the control group, $p < 0.001$. In the PF group there were 19 of the 65 pupils, (29%) who could not balance on one foot as compared to 28 out of 66 (42%) in the first examination. In the control group there were only 4 out of the 64 pupils (6%) compared to 8 out of 67 (12%) in the first examination who could not carry out the test successfully, (table 26).

In a comparison of the ability to balance on one foot, between the pupils with faulty posture who had done exercises and the others in the PF group, there was no difference between the two groups.

When the total material was divided with regard to age, an improvement of the ability to balance on one foot was found mainly in the older age groups.

Table 26. Distribution of the ability to balance on one foot, according to postural fault group (PF) and control group.

<u>First examination</u>				<u>Second examination</u>				<u>p</u>
<u>n</u>	Difficulties to perform the balance test	Can perform the balance test	<u>n</u>	Difficulties to perform the balance test	Can perform the balance test			
<u>PF group</u>								
Total	66	28	38	65	19	46	<0.001 ^{x/}	
Boys	33	14	19	32	9	23	0.02 ^{xx/}	
Girls	33	14	19	33	10	23	0.01 ^{xx/}	
<u>Control group</u>								
Total	67	8	59	64	4	60		
Boys	34	5	29	33	2	31		
Girls	33	3	30	31	2	29		
x/	Comparison between PF group and control group							
xx/	Comparison between boys and girls in PF group and control group.							

DISCUSSION

One aim of this part of the study was to investigate, in a short-term follow-up, whether postural gymnastics have an effect, in the first place on postural faults, and thereafter on spinal mobility, muscle function and coordination.

Postural or corrective exercises have been recommended by many authors with the aim of improving posture and eliminating postural faults (Haglund 1923, Kragh 1936, Burt 1949, Bang and Bojlén 1950, Lowman and Young 1960, Tucker 1960, Williams 1965, Wiles and Sweetnam 1965, Wells 1966, Kendall and Kendall 1968, Seyffarth 1972, Rasch and Burke 1978, Brower and Nash 1979 and Galley and Forster 1982).

Few investigations, however, have been carried out to evaluate the effect of postural exercises in school children. Johansson (1953) reported that boys in class 4, who, during a period of 2 years, had been given postural exercises in addition to ordinary gymnastics at school, had improved their posture in 22% of the cases, while boys without specific postural training had improved their posture in 9%. The corresponding figures for girls were 36% and 41%, respectively. These assessments were made from photographs.

The same kind of investigation and evaluation of postural gymnastics was carried out by Ingelmark (1954). Like Johansson he found less difference in girls than in boys, independent of what type of exercises they were given.

Dullum and Goldschmidt (1976) investigated the effect of prophylactic training in posture in school children from the 1st to the 4th class. The study revealed significant differences both in sitting and standing posture between the pupils who had received postural training and the control group. Painful conditions in shoulder and neck muscles and head-ache occurred more frequently among children in the control group.

Arnesen et al. (1976) evaluated the effect of ergonomics in the class-room given to children in classes 1, 2 and 3 for a period of one to two years, 10 minutes a day. The result of these efforts showed that the children who had been given this class-room training had improved by 30%, while the controls were unaltered with respect to posture. The assessments were made from side-view photographs.

In all previously mentioned investigations the postural exercises were given to whole classes for an extended period, and were thus integrated in the ordinary school work. This is probably, from the pupils' point of view, a better method than individual exercises, as in the present study, since no one needs to feel specifically penalized (Hertzberg 1976 and Randers Pehrson 1976).

On the other hand, one loses the opportunity of giving individual instructions to a pupil, which is sometimes of great importance, if class-room gymnastics is used as the only method.

In the present study, only those children were counted who, in the second examination were assessed as having a quite "normal" posture. This was the case with two girls in the ninth class belonging to the postural fault group. This method of re-assessment, however, offered no possibility to assess minor improvements of the pupils' posture. For this purpose an objective method should be used, for instance, the spinal pantograph.

Since slight improvements are not included in the present study, the results cannot be compared with those from other investigations.

Over and above the effect of improving the child's posture, additional effects of postural exercises, given as class-room training, have been reported by Arnesen et al. (1976). In the re-assessment two years after the class-room training had started, they found that the only two physical variables that

had improved in the school-classes exposed to this training, were trunk flexion strength and extensibility of the hamstring muscles. Mobility of the spine, trunk extension and the strength of the lower extremities had changed equally in all classes irrespective of training.

In the present study there appeared no difference concerning flexibility of the spine, when the training group was compared with the remainder of the group having postural faults or with the control group at the re-examination.

In the postural training, exercises to improve the mobility of the spine were not given as a routine, but were used mainly for children with a stiff and a marked kyphosis.

The postural training included exercises such as curl ups for strengthening the abdominal muscles. Trunk flexion strength increased significantly in the group that had trained. It increased, however, to the same extent in the untrained group as well as in the control group. The difference concerning trunk flexion strength between the postural fault group and the control group persisted.

The training programme also included exercises for the activation and control of trunk extensors. There was a uniform increase of the muscle strength which was not influenced by training.

Muscular tightness of the pectorals showed a significant decrease in the training group ($p = 0.01$). There still remained more pupils in the postural fault group who were assessed as having less extensibility of their pectorals than in the control group, and still the girls were more supple than the boys.

Tightness of the hamstrings was most pronounced in the postural fault group but decreased significantly among the boys in the training group. At the same time the tightness increased in the remainder of the boys in the PF group.

There were still significant differences concerning tightness of the hamstring muscles, between children in the postural fault group and the control group for boys as well as for girls.

The postural training programme contained stretching exercises for, above all, short pectoral and hamstring muscles.

Out of nine pupils in the postural fault group who had had difficulties in performing the rhythmic jumps during the first examination, now 6 of them were able to perform the test satisfactorily. Of these, three pupils had participated in the postural training and three had not. Also three pupils in the control group had improved.

This improvement was more marked in the younger age groups, where most difficulties to do the rhythmic jumps were seen in the first examination.

The ability to balance on one foot had not improved to a greater extent in the training group than in the remainder of the PF group.

The difference between children in the control group and the postural fault group persisted, for boys as well as for girls. Exercises for improving balance were not included in the postural training programme.

SUMMARY

In order to investigate whether postural gymnastics in a short-term follow-up have an effect on postural faults and on the flexibility of the spine, trunk muscle strength, muscular tightness and coordination, half of the children in the

postural fault group were chosen at random to participate in postural training.

The attitude to postural exercises and the attendance at the training sessions was studied.

In the re-assessment six to eight months after the first examination, only two pupils from the PF group, 2 girls in the ninth class, were judged no longer to have a postural fault. These two girls belonged to the training group. The improvement was, however, not related to the training intensity. Slight improvements may have appeared both in the children who had been training and those who had not, but the documentation of these changes would necessitate an objective measurement.

The postural gymnastics given seems, thus, not to result in any great improvements of the childrens' posture.

During the same period, 3 pupils, one boy and two girls from the 7th class, who belonged to the control group, had developed a postural fault.

The postural gymnastics given consisted to a great extent of stretching exercises, muscle strength exercises and exercises to control and change the position of the pelvis. Exercises to improve the mobility of the spine were used mainly in children with a stiff and marked kyphosis, and were thus not given as a routine.

There appeared in the re-examination with respect to muscular tightness of the pectoral and hamstring muscles, a difference between the boys in the training group and the remainder of the boys in the postural fault group, which could possibly be counted as an effect of the training.

Muscle tightness was generally less pronounced in girls.

Concerning other physical variables, such as the mobility of the spine, trunk muscle strength and coordination, no difference which could be attributed to the postural gymnastics, could be seen.

V. ASSESSMENT OF INTEREST AND PARTICIPATION IN PHYSICAL ACTIVITIES AND IN SCHOOL WORK.

One aim of the study was to investigate whether children with postural faults differ from a control group with respect to physical activities and school work.

The teachers who had been involved in teaching gymnastics and those who had been class teachers for the pupils who were included in the previous investigation were asked to give a written assessment of the pupils' interest and participation in physical activities at school and in their school work.

All the 6 teachers involved in gymnastics and the 22 class teachers participated in these assessments.

The assessments were made on a total of 129 pupils, i.e. all the pupils who partook in the second examination (5 pupils had moved from town or changed school during the time of the investigation).

There were 65 pupils, 32 boys and 33 girls belonging to the postural fault group and 64 pupils, 33 boys and 31 girls, in the control group.

The marks "below average", "average" and "above average" were used. The names of the pupils were listed in alphabetical order, so that no indication was given as to which group the pupils belonged.

RESULTS

There was a significant difference in the assessments given to the postural fault group and the control group concerning both interest and participation in physical activities as well as in school work, $p = 0.01$ and $p = 0.05$, respectively, (figs. 30 a and 30 b).

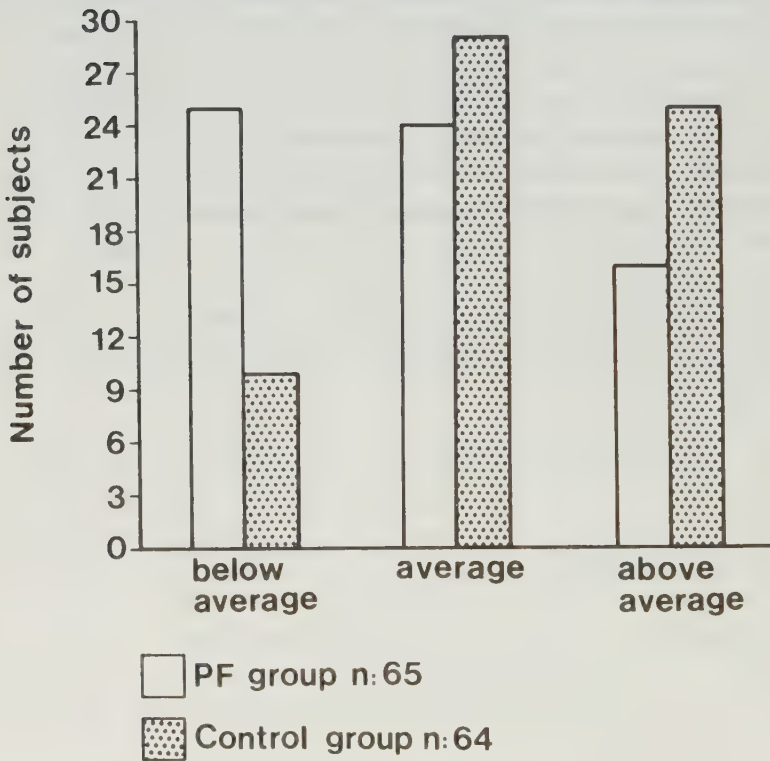


Fig. 30 a. Assessment of interest and participation in physical activities, $p = 0.01$.

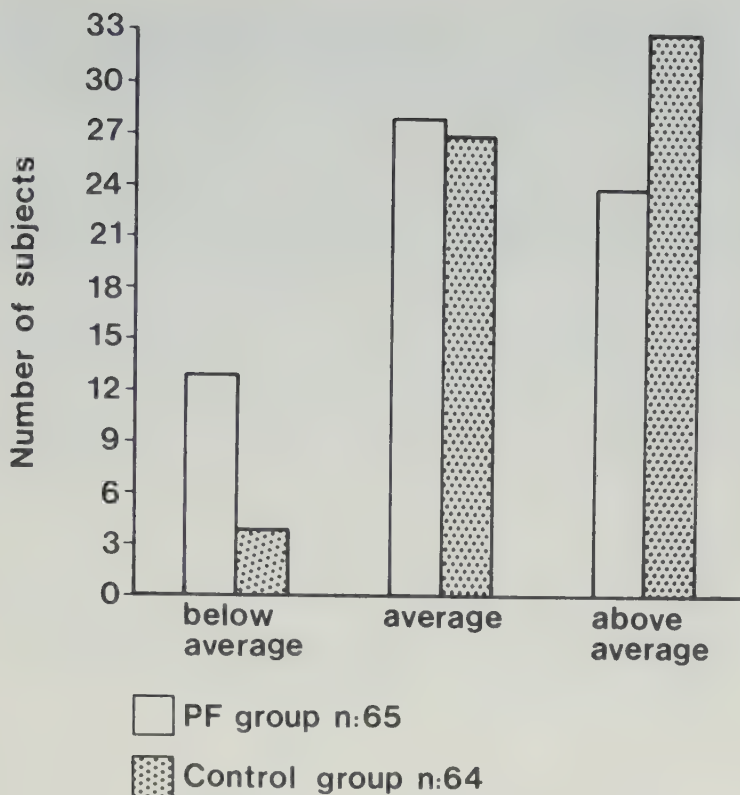


Fig. 30 b. Assessment of interest and participation in school work, $p = 0.05$.

Altogether 35 of the 129 pupils (27%) were judged as "below average" by the gymnastics teachers. Of these, 25 belonged to the postural fault group and 10 to the control group. The class teachers gave the same mark to 17 pupils (13%), of which 13 pupils belonged to the PF group and 4 to the control group.

The mark "above average" was given by the gymnastics teachers and the class teachers to 16 and 24 pupils, respectively, in the PF group, and to 25 and 33 pupils, respectively, in the control group.

There was a total of 55 pupils (43%) of the 129 who had been given the same mark by the two categories of teachers.

The co-variation between interest and participation in physical activities and school work was more evident concerning pupils in the postural fault group with respect to the mark "below average", where 10 out of 11 pupils belonged to the postural fault group. Concerning the mark "above average" the 15 pupils, out of the 19 with this mark, given by both categories of teachers, belonged to the control group, (table 27).

Table 27. Distribution of the number of pupils given identical marks by the gymnastics teachers and the class teachers (n = 129).

	Gymnastics teachers	Class teachers	Identical marks
Below average	35	17	11 (10 PF [*])
Average	53	55	25 (10 PF)
Above average	41	57	19 (4 PF)

* PF = postural fault group (n = 65).

Voluntary physical activities

Frequency of voluntary physical activities

All pupils who were involved in the second investigation were asked whether they partook with a certain regularity in any type of physical activity in their spare time.

In the postural fault group, 37 of the 65 pupils, (57%), and in the control group, 44 of the 64 pupils, (69%), reported participation in physical activities, as a pastime.

There was no significant difference in the participation in these activities between the PF group and the control group, $p = 0.16$.

When the material was divided according to sex it appeared that 24 of the 33 boys in the control group and 14 of the 32 boys in the postural fault group were involved in voluntary physical activities. The difference was significant, $p = 0.02$.

Among the girls, it appeared that there was about the same number in both groups who were involved in voluntary physical activities, $p = 0.66$. In the control group, the boys and girls partook to the same extent in voluntary physical activities, while in the PF group there were significantly more girls than boys who were involved in physical activities, $p = 0.03$.

Type of voluntary physical activity

The choice of activity varied greatly, particularly between the sexes. Concerning the most popular activities, there were also differences between the postural fault group and the control group, especially among the girls.

Gymnastics, dancing and ballet were by far the most frequently chosen activities among the girls in the control group, in

which 12 of 20 girls had chosen one or a combination of these activities. The 23 girls in the PF group who had some kind of physical activity were more involved in such activities as handball and horse riding.

Tennis, badminton and squash dominated among the boys, followed by soccer. The difference between the postural fault group and the control group was less marked among the boys than among the girls, (fig. 31).

Activities such as karate, table tennis, swimming, golf, muscular training, boxing etc. were less frequently chosen in all groups.

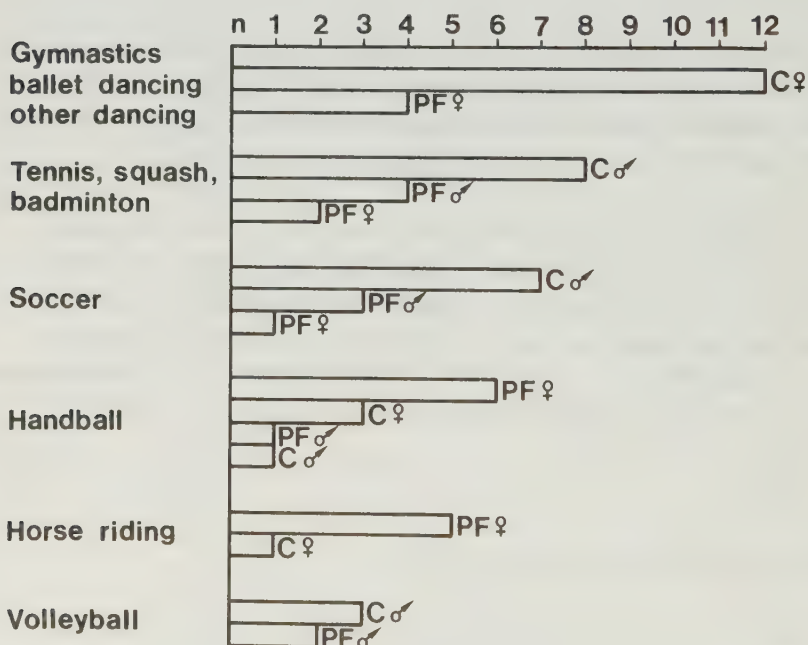


Fig. 31. Distribution of the most common voluntary physical activities, according to postural fault group (PF), control group (C) and sex.

DISCUSSION

In order to get a better understanding of the pupils' interest and participation in physical activities and in school work, and to find out whether there is a difference in this respect between children with postural faults and those without, the gymnastics teachers and the class teachers involved were asked to give a written assessment of each child.

Further, the aim was to study whether there is a correlation between interest in physical activities and in school work, and to what extent the pupils participated in voluntary physical activities.

Adler (1981/82) compared children with problems in physical education at school with those without such problems, with regard to their family situation, their opinion of physical education and sports, their relationship with school mates and their school achievements. He found that problems in physical education are connected with, for example, poor results in other school subjects and poor interest in physical education, postural education and sports at school.

In another study Adler (1982 a) claims that children with problems in physical education need additional attention and care at school, as half of these children have, what he calls, a multi-problem situation.

From a follow-up study Adler (1982 b) also reported that children with problems in gymnastics and physical education appeared still, even six years after the primary investigation in the third class, to have vestiges of these problems.

Gubbay (1975) reported "clumsy children" to be significantly below average in sporting ability compared with controls. This was also found by Sell et al. (1975).

In the present study there was a significant difference between the pupils in the postural fault group and the control group,

with respect to the assessment made by the gymnastics teachers as well as the class teachers. More pupils in the PF group were given the mark "below average", while the mark "above average" was given to a greater extent to pupils in the control group.

In 43% of the cases in the present study the same mark was given by the two categories of teachers, and concerning the mark "below average" the agreement was very good for pupils with a postural fault. There was thus, also in the present study, a certain co-variation between having a postural fault and taking less interest in physical activities at school as well as in school work.

Engström (1972); reported that he had found a correlation between interest and participation in physical activities both at school and in the pupils' spare time and success in school work. Setterlind (1975) found that children with a weak motivation for attending gymnastics lessons, competitions and sports days were also more negative to going to school at all, in comparison with a control group. Their marks, however, differed significantly only with respect to school gymnastics, but not to other school subjects in comparison with the control group.

In the present study girls in the postural fault group and the control group did voluntary physical activities to almost the same extent. Boys in the postural fault group, however, were significantly less involved in voluntary activities than boys in the control group.

There was, thus, with regard to the participation in voluntary activities very little difference between the girls in the two groups, but regarding the type of activity there appeared interesting differences. Girls in the control group had chosen activities such as gymnastics, dancing and ballet in most of the cases, while girls in the postural fault group had predominantly chosen activities such as handball and horse riding. These differences concerning the choice of physical

activity were not as pronounced between the two groups of boys.

It is, however, difficult to draw any certain conclusions from these results. Do children choose activities they possibly could be good at, or are there other factors involved, for example, following the choice of their best mates, their parents' wishes or the availability?

Gymnastics, dancing and ballet are activities that demand a very well developed coordination and muscular sense.

For this reason, both boys and girls with a postural fault who, according to the present study, have defective coordination, are not attracted by this type of activity.

SUMMARY

The gymnastics teachers and the class teachers involved, were asked to give a written assessment of the pupils' interest and participation in physical activities and in school work. Both categories of teachers gave significantly more pupils in the postural fault group the mark "below average", while more pupils in the control group were assessed as being "above average".

The pupils' participation in voluntary physical activities in their spare time, and the type of activity chosen, were also studied.

A difference concerning choice of activities was observed, mostly between the girls in the two groups.

Boys with postural faults were less interested in voluntary physical activities than boys in the control group.

GENERAL DISCUSSION

School children in classes 1, 4, 7 and 9, corresponding to the mean ages 7, 11, 14 and 16 years, respectively, at Järnåkra School in Lund were examined with respect to their posture, in combination with the routine health examination.

One aim of the present study was to arrive at a definition of the term "postural fault" to be practically used in school health care. The definition of "postural fault" was worked out jointly by the school doctor and the school nurse at Järnåkra School in Lund in co-operation with the author.

The types of postural faults described, represent the most common divergences from the so-called "normal" or "average" posture. Slight irregularities such as a decreased kyphosis or a flat back only, were thus not considered as a postural fault. Only those children were picked out whose postural faults were considered to be of such gravity as to require postural gymnastics.

The classification of postural faults used in the present study, similar to that originally described by Staffel (1889), is more reliable and easier to teach and use in, for example, school health care than, for instance the classification recommended by the Department of Hygiene and Physical Education, Harvard University (1916) which grades posture and postural faults from A to D, where A stands for "excellent mechanical use of the body" and D stands for "very poor mechanical use of the body".

The frequency of postural faults observed in the present study increased from about 4% in the first class to 16% in the ninth class. There was an equal number of boys and girls in all age groups regarded as having postural faults.

In the literature the frequency of postural faults in children varies between 10 and 95%. It seems, however, very unlikely that the frequency of postural faults in children could be as

high as 95% and quite different than in the present study, must have been used in the assessments of posture and postural faults. This does point to the need for simple, useful and comparable definitions of posture and postural faults and to the necessity of finding reliable methods for quantifying these postural faults.

In the present study, objective registrations of posture and postural faults were carried out by means of the spinal pantograph. By the aid of this instrument it is possible to quantify the magnitude of the sagittal curves of the spine as well as the anterior-posterior deviation of the trunk. The result of these examinations showed that there were significant differences concerning thoracic kyphosis, lumbar lordosis and the anterior-posterior deviation of the trunk, between children belonging to the postural fault group and children having a so called "normal" or "average" posture. A similar comparative study has not been published before.

A side-view photograph was also found to be as practicable and reliable as a direct subjective assessment when judging the posture of the child. The photograph, especially when using a cross-ruled curtain as a background, provides a convenient way to get an idea of the magnitude of the sagittal curves of the spine and the anterior-posterior deviation of the trunk.

Spinal pantography, thus, seems to be a very useful method in the attempts to describe posture and to quantify a postural fault, and could therefore be recommended for use on pupils as early as in the first class to register possible divergences of the posture. Follow-up studies could then be carried out annually by the school nurse on children with postural divergences or borderline cases in order to keep an eye on the development of the posture of the child.

Back pain has in the literature been considered by some authors to be a result of a postural fault (Brown 1917, Burt 1949, Bang and Bojlén 1950 and Engbaek 1974). In the present study the

frequency of back pain was higher in children having a postural fault than in the remainder of the total material. The difference was, however, less pronounced in the matched groups.

Some authors have found a certain correlation between low back pain and extreme gymnastic exercise, especially in young female athletes (Oseid et al. 1974, Micheli 1979, Spangfort 1981 and Wredmark et al. 1983). They also reported a correlation between low back pain and hyperlordosis.

This correlation was also found in the present study, but here without any connection with athletic exercises. As hyperlordosis is one of the most common types and one of the most marked features of postural faults, attempts should be made to find these cases early in order to, if possible, prevent further development of a too marked lordosis which could possibly give rise to a predisposition to low back pain.

It was also found in the present study that pain from parts of the locomotor system other than the back was even more common than back pain. There was an equal number of boys and girls reporting this kind of pain, and especially knee problems were very common in children in the older age groups. Further, significantly more pupils in the postural fault group reported pain from the locomotor system other than the back.

Thus, children with postural faults seem to be more susceptible to pain in the entire locomotor system. This is perhaps an expression of greater sensitivity to pain, or a result of inferior trunk muscle strength, muscle tightness and defective coordination which could give rise to abnormal loading of joint structures. Joints, which are exposed to loading in their extreme range of motion for a longer period, often react with pain (Harms-Ringdahl, 1981).

Micheli (1979) found a correlation between low back pain and hyperlordosis in combination with a tight lumbodorsal fascia, tight hamstrings and weak abdominal muscles. He suggests that one important factor, predisposing to back injury in the young

athlete is what happens in the adolescent growth spurt. The soft tissues, ligaments, muscles and tendons are unable to keep up with the growth of the bony elements which, thus, can result in imbalances across the joints, including the spine.

Muscle tightness was found in the present study mainly in the hamstring muscles, and more frequently in children having a postural fault. Children with postural fault, type I, i.e. with an increased kyphosis and rounded shoulders, had shorter pectorals than other children in the investigation. Further, a more pronounced tightness was found in boys and in the older age groups, which is also in conformity with statements made by Rasch and Burke (1978) and Micheli (1979). Micheli also points out that soft tissues are not able to keep up with the growth of the bony elements. This can, however, not explain the difference regarding muscle tightness between the postural fault group and the control group, as the growth rate was equal in the two groups.

Imbalance of hip and trunk muscles, with regard to muscle tightness as well as to muscle strength has been discussed by many authors as an important factor in the development of postural faults (Flint and Diehl 1961, Wells 1966, Kendall and Kendall 1968, Kendall et al. 1975, and Micheli 1979). Extremely short hamstring muscles have been reported in connection with Scheuermann's disease by, among others, Fisk and Baigent (1981). Phalen and Dickson (1961) described the correlation between tight hamstrings and spondylolistheses, especially common in girls aged 10 to 16 years. Other lumbar diseases in different ways irritating the cauda equina, correlated with extremely tight hamstrings were described by Spangfort (1978). Similar conditions were also reported by Fürmeier (1946/47).

The finding of shortened hamstrings may thus be a non-specific indication of spinal abnormality.

In the present study no significant difference concerning spinal forward flexion was found in the comparison between children in the postural fault group and the control group.

The method used, the steel tape measuring method, recommended by The American Academy of Orthopaedic Surgeons (1965), originally described by Schober (1937) is perhaps not accurate enough or the most suitable method to detect smaller differences, when flexibility is studied.

Mobility studies for the thoracic and the lumbar spine, separately, should thus be added, and thoracic extension should be tested, above all, on children having an increased thoracic kyphosis. The instrument to recommend for this kind of mobility measurement is the kyphometer.

Trunk muscle strength in the present study was significantly lower in the postural fault group than in the control group. Within the postural fault group, however, there was no difference with respect to trunk muscle strength between children having different types of postural fault. These results are in conformity with the results reported by Flint (1963) who found no significant relationship between the degree of lumbar lordosis and abdominal strength, back-extensor strength or hip flexibility.

The question as to whether impaired trunk muscle strength is implicated in the development of postural faults is, however, not yet answered. Normally the demands for muscular activity during upright standing are very small. Further, there is no indication, that "the stronger the muscles the better the posture" (Wells 1966).

No causal connection between slightly impaired trunk muscle strength and postural faults has been proved. These two factors may rather be an expression for the same condition; in the first place a decreased tonus of the trunk muscles in combination with an impaired kinesthetic awareness in the adjustments of the posture.

Not previously reported, is the observation made in the present study, that the ability to balance on one foot was significantly inferior in children with a postural fault compared to children without postural fault.

Further, children in the postural fault group were given lower marks by their gymnastics teachers concerning their interest and participation in physical activities at school, than were given to children in the control group. Besides, boys in the postural fault group partook less in voluntary physical activities in their leisure time than boys in the control group.

In girls, these differences were not seen, but an interesting result was the difference in the kind of voluntary activities chosen in the two groups. Girls in the postural fault group were involved in, above all, handball and horse riding, while girls in the control group had chosen activities such as gymnastics, dancing and ballet.

Furthermore, children in the postural fault group were given significantly lower marks than children in the control group also by their class teachers concerning their interest and participation in school work.

It seems, thus, that children having a postural fault not only have divergences with respect to their body posture, with, for example increased sagittal curves of the spine, improper body alignment, inferior trunk muscle strength, more pronounced muscular tightness and an impaired coordination. There appear, in addition to this, with increasing age, signs of a diminished intellectual activity. This could be an expression of a general feebleness and lessened vitality during the pre-puberal and puberal stages, possibly predisposing to inferior interest and results in both physical education and activities, as well as in other school subjects.

These findings are in conformity with results reported by, among others, Engström (1972), Setterlind (1975) and Adler (1981/82, 1982 a, 1982 b).

With this knowledge, it seems very important, that major attention should be paid to the child's total situation and not only to the increased sagittal curves of the spine.

In the present study, the postural gymnastics did not seem to have such a great effect on the postural fault, that the postural divergences were eliminated. With another approach, for example, less on the voluntary basis but given as a compulsory subject, the result would possibly have been different. Probably the best result will be achieved, however, if the child itself experiences a very strong wish to change and improve his posture.

In the present study, the aim was to reflect the present routine used at Järnåkra School, concerning postural gymnastics.

Regarding other effects of the postural gymnastics, it was obvious that muscular tightness could be reduced by stretching exercises. Other exercises, however, seemed not to have had any particular influence on either muscle strength or spinal mobility. Flexibility of the thoracic spine may have been improved, though not discovered in the steel tape measurements in those children who had been given such exercises, but yet not eliminating their postural fault.

Exercises to improve balance and coordination, not included in the postural training programme in the present study, seem to be worth testing in the efforts to improve muscle sense and body awareness in general, in order to prevent the development of a postural fault and to reduce and eliminate existing postural faults.

The most important factor is, however, to find those children at an early stage, who run the risk of developing this multi-problem situation. Increased attention and care and intellectual stimulation could then be given to them, in combination with more specific physical training and education.

Furthermore, a longitudinal study ought to be made, in order to gain a better knowledge of what happens to the child during childhood and adolescence with respect to posture, different physical variables and disposition to pain in the locomotor system, as well as to physical and intellectual ability at school.

GENERAL SUMMARY

One aim of the present study was to provide a definition of the term "postural fault" so that it could be practically used in school health care.

This definition was worked out jointly by the school doctor and the school nurse at Järnåkra School in Lund in co-operation with the author.

Further, the aim was to investigate the frequency of postural faults of such severity that they were regarded as requiring postural gymnastics.

The study comprised 589 school children in classes 1, 4, 7 and 9, corresponding to the mean ages 7, 11, 14 and 16 years, respectively, at Järnåkra School.

Out of these 589 pupils 11% were regarded as having a postural fault sufficiently grave that postural gymnastics were necessary. The number of children with postural faults increased from 4% in the 7 year-old children to 16% in the 16 year-old children. There was an equal number of boys and girls in all age groups having postural faults.

Twenty-six percent of the children in the entire material had a difference in the length of their legs, exceeding 5 mm, and a structural scoliosis was found in about 21% of the cases.

It was also the aim of the present study to investigate whether there is a correlation between postural faults and back pain. Of the 12% of the entire material who reported back pain, none were 7 year-olds, and of the 11 year-old pupils the only ones with back pain were girls.

Back pain was most common in the 16 year-old girls. In more than 95% of all cases having back pain, the lumbar spine was the site of the pain.

In the present study the frequency of back pain was higher in children having postural faults, and especially in girls having an increased lordosis, in comparison with the remainder of the entire material. In the matched groups, however, the difference in the frequency of back pain in the children was less pronounced.

Further, pain from parts of the locomotor system other than the back was reported in about 17% of the subjects, and this was especially common in the knee joints.

In order to investigate whether objective measurements of posture and postural faults agree with a direct subjective assessment of posture, a complementary study was carried out on 179 pupils, not involved in the other parts of the investigation. The objective measurements chosen were spinal pantography and moiré topography. The study shows that it is possible, by means of spinal pantography, to verify the direct subjective assessment of posture and postural faults with respect to the degree of thoracic kyphosis and lumbar lordosis as well as the anterior-posterior deviation of the trunk. There was also a good correlation, with regard to kyphosis and lordosis, in the comparison between the spinal pantography and the moiré topography. The former device seems, however, easier to handle and to make calculations from, and probably gives more correct values of the sagittal curves.

Further, side-view photographs were taken of the 179 pupils. The assessment of these photographs gave the same results as the direct subjective assessments of posture concerning the magnitude of the sagittal curves of the spine and the anterior-posterior deviation of the trunk.

A further aim of the study was to investigate whether children with postural faults differ from a control group with respect to physical variables, such as flexibility of the spine, trunk muscle strength, muscle tightness and coordination.

There were significant differences between the two groups regarding trunk muscle strength, tightness of the hamstring muscles and the coordination test of balancing on one foot. Other physical variables investigated, were found to be entirely comparable between the children in the postural fault group and children in the control group.

In order to investigate whether postural gymnastics, in a short-term follow-up, have an effect on postural faults and on the physical variables mentioned above, half of the children in the postural fault group were chosen at random to participate in a postural training programme.

The postural gymnastics comprised exercises to improve the strength and endurance of trunk muscles, stretching exercises, and exercises to control and correct the position of the pelvis. Exercises to improve spinal mobility were given mainly to children with an increased thoracic kyphosis. Information about sitting and working positions was also included, as well as instructions in lifting and carrying techniques.

At the re-assessment 6 to 8 months after the first examination, no marked effect on the postural faults of the postural gymnastics was found. Only two girls, both in the ninth class belonging to the training group, had improved their posture and were no longer considered as having a postural fault. The improvement was, however, not related to the intensity of the training. During the same period three pupils from the seventh class, who belonged to the control group, had developed a postural fault.

Muscle tightness was reduced in the training group, while in the remainder of the postural fault group muscle tightness increased.

There was a uniform increase of the trunk muscle strength in all groups, which was not influenced by training.

Flexibility of the spine was unchanged in all children tested, and the results were still entirely comparable between the postural fault group and the control group.

Coordination ability had improved to the same extent in the training group as in the remainder in the postural fault group. The difference persisted, however, with respect to balancing on one foot, between children having a postural fault and the control group.

In order to obtain a better understanding of the children's total situation at school, the gymnastics teachers and the class teachers involved were asked to give a written assessment of the pupils' interest and participation in physical activities and in school work. Both categories of teachers gave significantly more pupils in the postural fault group the mark "below average", while more pupils in the control group were given the mark "above average".

Further, the pupils' participation in voluntary physical activities in their spare time was studied. Boys in the postural fault group were less interested in voluntary activities than boys in the control group, while the girls in both groups partook to the same extent in voluntary physical activities. A difference concerning choice of activity, however, was seen between the girls in the two groups.

The result of the study shows that postural faults are only a part of a multi-problem situation. Major attention should therefore be paid to the child, with his individual characteristics and personality, in his interaction with his total environment, and not only to divergent sagittal curves of the spine.

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APPENDIX

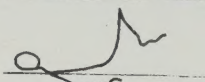
Postural gymnastics programme

1. To improve trunk flexion strength and endurance

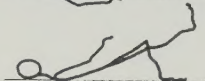
- a. by means of curl ups



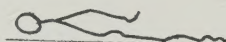
- b. by means of pelvic lifting



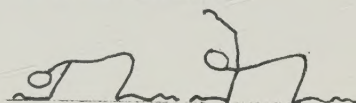
2. To improve pelvic control, and trunk and hip extension strength and endurance



3. To improve muscle control and thoracic spinal extension



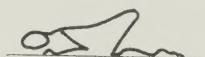
4. To improve the mobility of the thoracic spine in all directions



5. To improve thoracic spinal extension and strength of back extensors. Additional stretching of the pectoral muscles



6. Stretching of the pectoral muscles. "The caterpillar"



7. Stretching of the hamstring muscles

- a. in sitting position

- b. in standing position



The programme also included exercises to control and change the position of the pelvis from different initial positions, for example sitting and standing.

The pupils were also informed about sitting and working positions, as well as about lifting and carrying techniques.

